Is the school playground a suitable environment to enhance fundamental movement skills and promote a higher level of physical activity in primary school children? An ecological investigation to inform the development of a primary school playground intervention

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A thesis submitted in partial fulfilment of the requirements of Teesside University for the degree of Doctor of Philosophy

June 2020

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ABSTRACT

Higher levels of physical activity participation during childhood are believed to have beneficial effects on; 1) a number of cardio-metabolic risk factors (e.g., insulin resistance, hyperglycaemia, hyperlipidaemia, hypertension), 2) reducing the number of children leaving primary school obese, and; 3) psychological well-being. However, many children of primary school age (5 to 11 years old) do not achieve the current Chief Medical Officers (CMO) physical activity guidelines of an average of 60 minutes of moderate to vigorous physical activity (MVPA) per day, across the week.

Children who develop proficiency in Fundamental Movement Skills (FMS) are likely to participate in a higher level of MVPA throughout childhood and adolescence. Providing opportunities for children to develop their FMS is one strategy suggested to improve MVPA participation rates. The primary school playground is an environment where FMS and physical activity interventions can target large numbers of children at one time. Therefore, the collective aim of this thesis is to provide a critical exploration of how the primary school playground can be used to enhance FMS and MVPA levels in primary school children.

The first objective for this thesis was to complete a systematic review of previously conducted physical activity interventions aimed at increasing MVPA through development of FMS in primary school children (chapter 3). The Meta-analysis identified that physical activity interventions that included FMS had a pooled intervention effect (mean; 95%CI: 4.3; -0.03 to 8.8 minutes of MVPA per day) when compared to controls. This was above a minimal clinically important difference of 3.6 minutes of MVPA per day. There was substantial heterogeneity between studies (T = 7.6 minutes) that was largely explained by studies that accurately (R^2 = 0.85; T = 2.9) and fully conceptualised FMS (R^2 = 0.89; T = 2.5).

Following this, a case study assessment of current playground MVPA levels was completed using systematic observation methods (chapter 4). The objective was to measure the number of MVPA episodes on the playground during break-times and to identify the effect of

environmental and contextual characteristics on the proportion of break-time MVPA episodes. Overall, there were low levels of MVPA observed during break-times. Areas which promoted the highest levels of MVPA on the playground were areas that promoted climbing, team sports and adventure play. There were beneficial effects of appropriate adult supervision (incidence rate ratio (RR) and 95% CI; 1.34; 1.18 to 1.53) and organisation (2.70; 1.87 to 3.91) on MVPA levels, whilst the provision of free play equipment had a negative effect on MVPA levels (0.85; 0.75 to 0.96).

Chapter 4 was followed by a socio-ecological exploration (survey), examining individual, social and environmental factors of the playground that children (5 to 11 years old) enjoyed during break-times (chapter 5). Chapter 5 highlighted subtle gender and age group differences in individual survey items. Although the chapters 4 and 5 were conducted independently, there were outcomes from chapter 5 which provided insight to children's playground behaviours observed in chapter 4. For example, female children were observed more frequently in areas promoting social interaction in chapter 4; whilst also reporting highest levels of enjoyment for 'talking with friends' in chapter 5. Overall, the highest levels of self-reported enjoyment for all children were recorded at a social level ('playing with friends' and 'talking with friends'). As the findings from chapter 5 are a manifestation of children's enjoyment of the playground currently available to them, a further socio-ecological, qualitative exploration (focus groups, interviews and questionnaires) was completed in chapter 6 to identify the barriers and facilitators to a physically active break-time from the perspective of school children and school staff.

Barriers and facilitators were identified at all levels of the socio-ecological model (individual, social, environmental and policy) from child and adult (Teachers, sports coaches, playground supervisors) perspectives. Friendship and positive peer relationships (social) were again a key factor in facilitating physical activity, and deciding which play spaces to engage with during break-times. Furthermore, perceptions of physical competence (individual), enjoyment of activities (individual) and space available (environmental) were identified as reasons why children either did or did not engage with certain activities. It was concluded from chapter 6 that there was a collective lack of sustainable investment (time and monetary) in the primary school playground during break-times. Finally, a key findings from the final exploratory chapters (chapter 5 and 6) was the very different perception of the role and importance of break-times between the adults (staff) and the children (pupil) participants. Differences between the child and adult agenda and the child embodiment of adultist views acts to restrict children physical activity levels during school break-times.

The thesis concludes by presenting a proposed playground intervention (design and development) cross referenced to each of the key outcomes from the previous chapters. Practical and research implications are discussed and future directions presented with the joint aim of improving the current under-utilisation of the primary school playground for FMS development and MVPA participation.

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ABBREVIATIONS

ANOVA	Analysis of Variance
B	Balance
BMI	Body Mass Index
BOT	Bruininks-Oseretsky Test
CAMSA	Canadian Agility and Movement skill Assessment
CHAMPS	Children’s Activity and Movement in Preschool Study
CI	Confidence Interval
CL	Confidence Limits
CMO	Chief Medical Officer
CMSP	CHAMPS Motor Skills Protocol
CPM	Counts Per Minute
CRF	Cardio-respiratory Fitness
CYP	Children and Young People
DC	Dragon Challenge
DCD	Developmental Coordination Disorder
DfE	Department for Education
DoH	Department of Health
DTA	Deductive Thematic Analysis
EAPRS	Environment Assessment of Public Recreation Spaces
EYHS	European Youth Heart Survey
FMS	Fundamental Movement Skills
GMQ	Gross Motor Quotient
HRF	Health Related Fitness

HSE	Health Survey for England
IBDS	Iowa Bone Development Study
ICAD	International Children’s Accelerometer Database
ICC	Inter-Class Correlation Coefficient
IMD	Index of Multiple Deprivation
IOA	Inter-observer Agreement
IRR	Inter-rater Reliability
KS	Key Stage
KTK	KörperkoordinationsTest Für Kinder
L	Locomotor
LA	Low Autonomy
LEAP	Lunchtime Enjoyment of Activities and Play
LPA	Light Physical Activity
MABC	Movement Assessment Battery for Children
MAT	Movement Assessment Tool
MBI	Magnitude Based Inference
MCID	Minimal Clinically Important Difference
METs	Metabolic Equivalents
METy	Metabolic Equivalent for youth
MMC	Mastery Motivational Climate
MMT	Maastrichtse Motoriektest
MPA	Moderate Physical Activity
MRC	Medical Research Council
MUGA	Multi Use Games Area

MVPA	Moderate to Vigorous Physical Activity
NCMP	National Child Measurement Programme
OC	Object Control
OFSTED	Office for Standards in Education
PAG	Participant Advisory Group
PDMS	Peabody Developmental Motor Scales
PE	Physical Education
PM’s	Playground Master’s
POC	Process-Oriented Checklist
PPESP	Primary Physical Education and Sport Premium
PPI	Patient and Public Involvement
RAE	Relative Age Effect
RCT	Randomised Control Trial
RMR	Resting Metabolic Rate
RR	Rate Ratio
SAAFE	Supportive, Active, Autonomous, Fair, Enjoyable
SCORES	Supporting Children’s Outcomes using Rewards, Exercise and Skills
SD	Standard Deviation
SE	Standard Error
SED	Sedentary
SEM	Socio-Ecological Model
SEN	Special Educational Needs
SES	Socio-Economic Status
SESOI	Smallest Effect Size Of Interest

SMD	Standardised Mean Difference
SOPLAY	System for Observing Play and Leisure Activity in Youth
SOCARP	System for Observing Children's Activity and Relationships during Play
SPARK	Sports, Play and Active Rewards for Kids
TA	Total activity
TGMD	Test of Gross Motor Development
VPA	Vigorous Physical Activity
WHO	World Health Organisation

THESIS OUTPUTS

Conference communications from thesis

1. **Graham M**. Using systematic observation to measure physical activity levels of primary school children during break-time: issues, challenges and insight from an observation study. Yorkshire and Humber Physical Activity Knowledge Exchange (YoHPAKE) 2nd Annual conference; Enabling active communities: Play your part. Leeds Beckett University, Leeds. January 2018, Poster presentation

2. **Graham M**., Batterham AM., Azevedo LB., Wright MD., & Innerd A. Does the playground environment matter? Physical activity levels of 5 to 11 year olds in the school playground - an observational case study. Bi-annual Stockton and Redcar active schools conference. January 2019 – Oral presentation

3. **Graham M**., Batterham AM., Azevedo LB., Wright MD., & Innerd A. The school playground environment as a driver of primary school children's physical activity behaviour: A mensurative case study. Teesside University Post-Graduate research conference. September 2019 – Oral presentation

4. **Graham M**., Azevedo LB., Wright MD., & Innerd A. The effect of fundamental movement skill interventions on moderate to vigorous physical activity levels in 5 to 11 year olds: a systematic review and Meta-analysis. Teesside University post-graduate research conference – September 2019 – Poster presentation – Best poster award.

Research outputs not related to PhD

1. Hynd J., Cooley D., **Graham M.** (2017) Saddle tilt during uphill cycling improves perceived comfort levels, with corresponding effects on saddle pressure in highly trained cyclists. 4th Science in Cycling Conference, Dusseldorf, Germany. Abstract from oral presentation. *Journal of Science and Cycling;* 6(3): p.36-38

2. Peart DJ., **Graham M**., Blades C., Walshe IH. (2020). The Effect of Carbohydrate Mouth Rinsing on Multiple Choice Reaction Time During Amateur Boxing. *International Journal of Sports Physiology and Performance;* 15(5): p.720-723. https://doi.org/10.1123/ijspp.2019-0485

ACKNOWLEDGEMENTS

First and foremost I would like to thank the head teachers, staff, pupils and parents for giving up their valuable time to participate in the studies which contributed to this thesis. Without their continued commitment this thesis would not have been possible.

I would also like to give my sincere thanks to my Director of Studies, Dr Alison Innerd, for her continuous support and compassion over the last three and a half years. Alison's time, expertise and ad-hoc discussions about my thesis made this an enjoyable experience. Without Alison's understanding during some difficult periods I do not think I would have completed my PhD thesis in this time frame.

I am extremely grateful to my supervisory team, Dr Liane Azevedo, Dr Matthew Wright and Professor Alan Batterham for their expert opinion and guidance. I would like to extend a special thank you to Professor Batterham and Dr Azevedo for their patience and expertise, especially relating to the methods and data analysis for chapters 3 and 4. I would also like to give a special thank you to Dr Wright for the support and discussion throughout this process.

Thank you to Tom Macpherson and Daniel Jones for their assistance with data collection (chapter 4) and to Dr Kevin Dixon and Dr Kevin Ions for their valuable guidance on qualitative data collection and analysis (chapter 6). Teesside University sport and exercise technical team (Daniel Cooley, Georgia Campbell, Stuart Brown & Ben Sherwood) for providing work space, technical assistance, sourcing equipment and the software programs needed for data collection and analysis, I thank you. Also, to the many academics who provided advice and guidance in the early days of my journey, this gave me a strong foundation on which to build.

I would like to thank all of my friends and family for their support over the years. I owe an enormous amount of gratitude to my parents for their advice, guidance and love. Without their support in the summer of 2004, I would not have had the courage to make an early career change from engineering and explore sport and health science. Finally, to my wife and daughter, thank you for your endless patience, love and grounding during this process.

I would like to dedicate this thesis to my Father, Ashley Graham, and my dog Boe, who both sadly, prematurely passed away during my PhD journey. Their strength and unconditional love provided me with an enormous amount of motivation.

Thank you

CHAPTER 1: INTRODUCTION

1.1 Introduction

"If physical activity were a drug, we would refer to it as a miracle cure, due to the great many illnesses it can prevent and help treat."

UK Chief medical officers' 2019 – pg.3

Physical activity has been recommended as an important health behaviour since ancient Greek practices of Hippocrates and Plato (around the 5th century BC). These early physicians identified being physically active as the desired "hexis" or state of being, and raised concern for the "diathesis" of athleticism (MacAuley 1994). Paracelsus, a 16th century physician, alchemist and professor of medicine, is famously quoted

"What is there that is not poison? All things are poison and nothing is without poison. Solely the dose determines that a thing is not a poison".

Paracelsus – dritte defensio, 1538

Paracelsus encouraged the theory that there is potential for beneficial or toxic effects in anything, and that it is the volume, frequency and intensity (i.e., the dose) of an agent (or behaviour) that is the important factor in the prescription. This phrase would seem to apply to both extremes of the physical activity spectrum in children, where very low levels of physical activity are associated with insulin resistance, hyperlipidaemia and hyperglycaemia (Ekelund, Anderssen, Froberg et al. 2007); whilst unnecessarily high levels of physical activity (e.g., youth athletes) are associated with overuse injuries, increased risk of infection; and physical and psychological burnout (Brenner 2007; Kreher and Schwartz 2012).

The current UK Chief Medical Officer's (CMO) message on physical activity for health is very clear, that "some is good, more is better" (UK Department of Health (DoH) 2019). However, this would seem to apply to individuals currently engaging in the lowest levels of physical activity, where relatively small increases in physical activity having the greatest impact.

Participation in physical activity beyond a somewhat extreme threshold of >600 minutes per week is unlikely to result in further health benefits (UK CMO Physical activity guidelines 2019; pg.14). However, the UK CMO reaffirms that the health benefits at this level far outweigh the risks of being active (UK DoH 2019) and are far from what would be considered a "toxic" amount. Moreover, observational and experimental studies in child populations have found that the more physical activity children take part in the greater the health benefit, with even modest amounts providing some benefit to those at a high risk of developing inactivity related disorders (e.g., obesity and type II diabetes) (Janssen and LeBlanc 2010). The physiological and psychological injury associated to the highest levels of physical activity participation (Brenner 2007; Kreher and Schwartz 2012) is likely to be a consequence of the intensity of activities and the sports related activities.

1.2 Physical activity and health

Physical activity behaviours during childhood have been shown to track into adulthood (Twisk, Kemper and Van Mechelen 2002; Stodden, Goodway, Langendorfer et al. 2008; Telama, Yang, Leskinen et al. 2014) with higher levels of physical activity associated with lower levels of risk factors for cardiovascular disease and type II diabetes risk factors in this population (Strong, Malina, Blimkie et al. 2005). Furthermore, physical activity of at least moderate intensity is an important contributor to living a long and healthy life, and contributes to the prevention of obesity and many mental health problems in children (Parfitt and Eston 2005; Janssen and Le Blanc 2010; UK DoH 2019).

The cardio-protective properties of engaging in moderate to vigorous physical activity (MVPA) are firmly established in children and adolescents (McMurray & Andersen 2010). Moreover, an increase in physical activity, specifically MVPA has beneficial effects on cardio-metabolic risk factors, irrespective of changes in other independent risk factors, such as obesity (Ekelund et al. 2007; Andersen, Sardinha, Forsberg et al. 2009). However, it is suggested three in four adolescents (WHO 2018) and less than half the UK's 7 to 8 year olds achieved the UK CMO physical activity guidelines from 2011, of at least 60 minutes MVPA per day (Griffiths, Cortina-Borja, Sera et al. 2013; Escalante, Garcia-Hermoso, Backx et al. 2014), suggested to be a major contributor to the increase rate of obesity in children (WHO 2017). When comparing physical activity levels from the previous year with the most recent report, physical activity levels have shown an increase of 3.6% in children (Sport England 2019). Despite this increase, physical activity levels remain low (Sport England 2019). Therefore it is not surprising that three of six key action areas in the WHO (2017) report on ending childhood obesity include physical activity.

There is a growing global concern regarding the rise in childhood obesity with 42 million pre-school children classed as overweight or obese in 2016 (WHO 2017). Data from the UK's national child measurement programme highlighted that one in five children are overweight or obese at aged 5; and one in three children being overweight or obese by the time they leave primary school at 11 years of age (UK DoH 2019). The 2007 foresight report on tackling the rising levels in obesity, indicated that in the absence of a sustainable solution, 25% of all children under 16 years of age could be obese by 2050, contributing to an increased economic burden of £49.9 billion per year (Foresight 2007). There are however, a number of benefits beyond the physical health protection that are positively associated with a higher level of physical activity in childhood.

An increase in physical activity levels is associated with an increase in psychological well-being (such as depression, anxiety and self-esteem) (Parfitt and Eston 2005). Furthermore, research has begun to identify causal associations between physical activity and some domains of mental health (Biddle, Ciaccioni, Thomas and Vergeer 2019). As the positive health outcomes of being physical active are likely to track into adulthood (Telama et al 2014) and reduce the risk of developing chronic diseases (WHO 2017), the promotion of physical activity among pre-school and primary school children is a key public health priority (Jiménez-Pavón, Kelly, Reilly 2010).

According to the recent CMO guidelines, children between the ages of 5 to 18 years should engage in MVPA for an average of at least 60 minutes per day across the week (UK DoH 2019). Self-reported data from the 2017/18 Active Lives survey for children and young people (CYP) (Sport England 2018), found that 17.5% of CYP met the previous recommended levels for physical activity and a worrying 33% or 2.3 million children were doing less than 30 minutes per day. Furthermore, previous self-reported measures of children's physical activity found that 32% of male and 24% of female children met the government's previous recommendations for physical activity (Health Survey for England: HSE 2008).

However, these were self-reported measures of physical activity and the use of self-report physical activity measurement have previously received criticism due to associated bias from misclassification and over/under-reporting of physical activity levels (Shephard 2003). The HSE (2008) acknowledged that their self-report measures may have under-estimated MVPA in younger children and over-estimated among older children. However, the HSE (2008) also measured physical activity using accelerometry and found similar levels for male (33%) and female children (21%) on meeting the government physical activity recommendations (HSE 2008).

In an attempt to address the poor adherence to physical activity guidelines in children, there has been a rise in the number and variety of physical activity interventions (for example, physical education (PE), active play, and multi-component) (McKenzie, Sallis, Kolody et al. 1997; O'Dwyer, Fairclough, Knowles & Stratton 2012; Rudd, Barnett, Farrow et al. 2017a; Morgan, Young, Barnes et al. 2018). However, a growing body of evidence suggests that the 'most effective solution' might differ somewhat between population subgroups (age, gender, ethnicity, socioeconomic status) and is dependent on the combination of biological and environmental influences on physical activity levels (Sherar, Cumming, Eisenmann et al. 2010).

1.3 Physical activity and the environment

One avenue that children channel their physical activity is through play (Fox, Cooper and McKenna 2004). An environment that fosters play offers the potential to contribute to an increasing level of MVPA (Escalante, Garcia-Hermoso, Backx and Saavedra 2014). However, the opportunities for children to engage in play-based physical activity are dependent on several factors (Ridgers, Stratton and Fairclough 2006), and opportunities for play in childhood are decreasing (Hofferth and Sandberg 2001). For example, poor provision of outdoor play facilities, an increase in parental anxieties about safety, increased urbanisation, a reduction in independent mobility (i.e., active transport), increase in sedentary leisure time activities (such as television viewing, and games consoles) have all previously been linked to a decreased engagement in more physically active behaviours (Sleap and Warburton 1996; Valentine and McKendrick 1997; Carver, Timperio and Crawford 2008; Carver, Timperio and Crawford 2017).

The primary school environment offers a safe and flexible setting to promote physical activity in children. Physical activity programmes could be easily integrated into existing domains within the curriculum with staff development and cohort inclusion costing no more than is typically required for existing programmes (Stone, McKenzie, Welk et al. 1998; Gråstén, Watt, Liukkonen et al. 2017). Furthermore, the use of school facilities, before and after-school might begin to address some of the parental concerns around neighbourhood safety and poor play provision.

However, quality of delivery, duration and intensity of the activity and poor uptake are some of the reasons that school-based physical activity programmes have failed at making sustainable impacts on physical activity levels in children (Morgan, Barnett, Cliff et al. 2013). Metcalfe, Henley and Wilkin (2013) suggested that what some investigators may be overlooking is the timing of the physical activity component of their interventions. For example, the activity component may simply replace a period of time that children would usually already be active (PE lesson) and by targeting the periods of the day where children are free to choose their activities without instruction might better suit attempts at increasing physical activity levels in children (Metcalfe et al. 2013).

School break-times (break and lunch-time) provide a substantial amount of opportunities for primary school children to engage in freely chosen play and physical activity (Ridgers, Carter, Stratton and McKenzie 2011). Break-times are an ideal context within the school day to promote physical activity as they are offered universally in UK primary schools (Baines and Blatchford 2019a) and targeting these periods in the day would not interfere with existing academic-focussed activities (Erwin, Ickes, Ahn & Fedewa 2014). Despite the evidence supporting the benefits of regular breaks on physical (O'Dwyer et al. 2012; Engelen, Bundy, Naughton et al. 2013; Erwin et al. 2014), social/emotional and psychological/cognitive (Pellegrini, Kato, Blatchford and Baines 2002; Ahn & Fedewa 2011) outcomes, there has been a marked decline in the amount of break-times provided to children at all school ages in the last 20 years (Baines and Blatchford 2019a). Children in key stage one (KS1) and key stage two (KS2) now receive an average of 45 minutes less break-time per week (Baines and Blatchford 2019b). Furthermore, the proportion of time provided for breaks during school time reduces for each stage of school (KS1 to KS4) (Baines and Blatchford 2019a), predominantly as result of curricular related pressures (Erwin et al. 2014; Baines and Blatchford 2019a). However, evidence suggests this is counterintuitive, as an increase in physical activity, within lesson time and whole day, can have beneficial effects of academic outcomes (Norris, van Steen, Direito and Stamatakis 2019).

The reduction in time available for break-times, paired with a large variation in playground environments (equipment provision, staffing, physical structures and surfaces) available to children during break-time (Mota, Silva, Santos et al. 2005; Ridgers, Stratton and Fairclough 2006; Ridgers, Fairclough & Stratton 2010; Saint-Maurice, Bai, Vazou, Welk 2018) results in varied levels of physical activity reported between studies using accelerometry (studies ranged from 2.7 to 18.4 minutes of MVPA). It is important to understand how children interact with their school playground as they age in order to provide safe, fun, engaging and developmentally appropriate opportunities for physical activity throughout the school years. For example zonal playgrounds (i.e., variety of zoned areas which provide a range of activities) with appropriate markings and physical structures (e.g., goal posts, basket-ball hoops, multi-use games areas (MUGA)) have previously been found to have a positive effect on primary school children's physical activity levels during school break and lunch-times (Ridgers et al. 2010). However, playground markings may be more appealing to younger age groups (Erwin et al. 2014) but as children become more accustomed to their school playground and begin to master early movement competencies (e.g., fundamental movement skills) they become less likely to engage in these existing activities (Hyndman and Chancellor 2015) and new, more interesting and challenging activities should be provided.

1.4 Importance of physical competence

Fundamental movement skill (FMS) competency is a primary underlying mechanism that promotes engagement in physical activity (Stodden et al. 2008). The development of FMS is important in children, particularly younger children, as it allows for the exploration of the physical environment (Logan, Robinson, and Getchell 2011) with effective and efficient movement (Giles 2011). FMS consist of three main constructs: locomotor (run, hop, jump, slide, gallop, leap); object control (strike, dribble, kick, throw, underarm roll, catch); and balance/stability skills (body rolling, bending and twisting) (Gallahue, Ozmun and Goodway 2012) and have been described as the "building blocks" of effective movement (Clarke and Metcalfe 2002). However, children who have yet to develop a foundation level of FMS competency may disengage on playing on a primary school playground with physical structures which promotes predominantly sporting activities. This could be due in part to FMS competency or perceived competency issues. Early development of FMS forms an essential foundation needed to develop more context specific movement skills in later life (Clark and Metcalfe 2002; Lloyd and Oliver 2012; Barnett, Stodden, Cohen et al. 2016a). An important part of FMS development is the level of coaching and modelling required to successfully master FMS (McKenzie, Alcaraz, Sallis et al. 1998; Stodden et al. 2008; Barnett et al. 2016a). This reinforces the need for quality PE focussed on the coaching and development of FMS and providing sufficient progress in children's movement skill competence to increase engagement in physical activity during other periods of time, such as break and lunch-times.

Much of the recent research has highlighted positive associations between FMS and physical activity in early year's children (Barnett, Lai, Veldman et al. 2016b; Cattuzzo, dos Santos Henrique, Ré et al. 2016; Van Capelle, Broderick, Van Doorn et al. 2017). However, the current evidence for the effectiveness of FMS interventions on physical activity levels in primary school children is contradictory (Salmon, Ball, Hume et al. 2008; Cohen, Morgan, Plotnikoff et al. 2015; Weber, Sporkel, Mertens et al. 2017; Adab, Pallan, Lancashire et al. 2018). Furthermore, exploring the current use of; and the potential for, the primary school playground to encourage participation in activities that develop FMS, and consequently a higher physical activity level is needed.

1.5 Definitions

To date, there continues to be a blurring of the terms 'physical activity', 'exercise' and 'physical fitness' (Dasso 2019). Physical activity is defined as any voluntary bodily movements or action produced by the contraction of skeletal muscles that results in energy expenditure above a basal level (Caspersen, Powell and Christenson 1985; Butte, Ekelund and Westerterp 2012). Further, the amount of energy expended is dependent on the amount of muscular activity required to perform the movement (Caspersen et al. 1985). Physical activity and exercise are similar in that they both result in energy expenditure as a consequence of skeletal muscle activation. However, exercise should be considered as a subcategory of physical activity that comprises planned, structured, repetitive activities for the purpose of maintaining or improving one of the components of physical fitness (Caspersen et al. 1985). An individual's fitness is not necessarily a direct consequence of their physical activity levels (Williams 2001), but they are associated (albeit weakly; Ekelund et al. 2007). In that the physical activity levels of an individual partly determine their fitness level (Blair, Cheng and Holder 2001). For example, a child which takes part in a large volume of vigorous physical activity habitually, is likely to have a higher cardio-respiratory fitness (CRF) than a child that takes part in a moderate amount of light to moderate physical activity.

However, physical activity and CRF affect metabolic health outcomes through different pathways and are associated with different confounders. For example, CRF is confounded by adiposity levels in children, whilst physical activity level is not (Lee, Bacha, Gungor Arsllanian 2006; Ekelund et al. 2007). Therefore, physical activity and CRF can be considered as separately, and independently associated with individual (insulin sensitivity, hyperglycaemia, hyperlipidaemia) and clustered metabolic risk factors in children (Brage, Wedderkopp, Ekelund et al. 2004; Ball, Shaibi, Cruz et al. 2004; Ekelund et al. 2007). Authors of these previous studies have highlighted the importance of these findings to public health, as increasing an individual's physical activity level is likely to have beneficial effects on multiple health outcomes, despite any change in CRF (Ekelund et al. 2007). This is particularly important, given that children may find it easier to take part in a greater amount of physical activity throughout the week during activities that are more appealing (through play for example) compared to more structured exercise sessions (PE, fitness classes, athletics and competitive sport).

For the remainder of this thesis, the aforementioned definitions will underpin the terminology used. In any instance where I refer to a specific category, the associated term will be used.

1.6 Research aims and objectives

Despite an increase in publications on physical activity interventions in children in recent years, there has also been an equal amount of publications criticising the methodological quality of intervention studies in children (van Sluijs, McMinn, Griffin 2007; Kriemler, Meyer, Martin et al. 2011; van Sluijs and Kriemler 2016). Van Sluijs and Kriemler (2016) suggest that intervention research should be built on a rigorous critical platform of intervention development. To increase the quality and impact of future interventions, van Sluijs and Kriemler (2016) recommend a number of key intervention mapping actions to be taken throughout the research process. Actively engaging with the individuals who the research projects are designed to target and integrating the views of the multi-level stakeholders (participants, delivery, senior management and policy makers) at the earliest opportunity in the planning process; and throughout design (patient and public involvement), implementation (qualitative examination) and evaluation (process evaluation), increases the likelihood of a successful and effective intervention (van Sluijs and Kriemler 2016). Outputs from the aforementioned activities can then be embedded within a comprehensive model for intervention development and refinement. The suggested actions (needs assessment, target population and theory) for improving the level of evidence for physical activity interventions in children, presented by van Sluijs and Kriemler (2016) will underpin each of the chapters for this thesis, ensuring a rigorous process of intervention optimisation (MRC 2008).

The collective aim of this thesis is to provide a critical understanding of how the primary school playground can be used to enhance FMS and physical activity levels in primary school children. Prior to the design of primary school playground intervention (chapter 8), it is important to establish a theoretical platform and needs assessment (chapter 3, 4, 5 and 6) on which to develop the core components of an intervention (van Sluijs and Kriemler 2016). The individual aims and objectives for the chapters in this thesis are presented in Table 1.1, with a framework for the thesis presented in Figure 1.1.

1.7 Research paradigm and PhD Framework

1.7.1 Researcher paradigm

My PhD journey began by exploring the theoretical and empirical literature so I could establish a credible foundation on which to construct my own research questions. This led to the development of a framework of individual studies that aligned to the existing view of how FMS affects physical activity participation. As a consequence of my previous undergraduate (BSc) and post-graduate (MSc) education in sports science following a predominantly post-positivistic paradigm of hypothesis testing to acquire knowledge, using solely quantitative research methods, my early PhD plan was influenced by this and contained a number of studies with a similar research emphasis. The post-positivistic paradigm acknowledges that researchers can discover a reality, contributing to a cause-effect model, but that it exist within a realm of probability rather than certainty, due to the human limitations (e.g., human error, conscious and unconscious biases) (Trochim 2002; Mertens 2009).

However, as the project of work developed and I, myself developed as a researcher, through a critical engagement with the literature and through academic discussion (conference attendance and networking), I began to value a more comprehensive and systematic method of conducting research. This moved the PhD from a predominantly quantitative methodology to using a mixed methods approach (combination of quantitative and qualitative methods) and aligned with a more constructionist epistemology. This allowed me to develop a deeper contextual understanding of the topic. I began to appreciate the value of a constructivist/interpretative paradigm, which identifies that reality and truth is somewhat socially constructed (Mertens 2009) and the individuals, their culture and the context in which research is conducted can influence this 'reality', and it is therefore important to consider how these assumptions can be built into the research process.

Therefore, the experimental chapters that follow are constructed around the idea that FMS are important to children's MVPA levels, however, physical activity participation within a primary school environment are a result of many individual, social and environmental factors that are also of importance when considering the most appropriate methods of increasing children's MVPA levels. The complex interaction between these factors may also mediate the effectiveness of FMS on MVPA levels.

1.7.2 PhD Framework

Outcomes from each chapter in this thesis will be used to inform the development of a primary school playground intervention, in line with the Medical Research Council (MRC) and National Institute for Health Research (NIHR) update to developing and evaluating complex interventions guidelines (2008) (Figure 1.1 and Figure 1.2 PhD study framework). The MRC (2008) suggest a thorough process of optimising an intervention prior to pilot evaluation.

Study one (chapter 3) provides a systematic review, including a narrative synthesis and meta-analysis of the current evidence regarding the effectiveness of FMS interventions in primary school age children on MVPA. This is novel as previous reviews in this area have concentrated predominantly on early years. A recent systematic review by Engel, Broderick, van Doorn et al. (2018) attempted to explore the relationship between FMS interventions and physical activity levels in children (between 3 and 12 years old). However, there were noticeable oversights in this article methodology (search strategy, screening, meta-analysis method, MVPA classification) and the findings presented, which obscured any true effect in primary school children (see discussion, chapter 3, pg.84 for more details).

The systematic review and meta-analysis presented in this thesis offers an original and valuable contribution to this subject area, highlighting interventions effects (minutes of MVPA) that varied widely in magnitude. A number of separate meta-regression models were created to explore the moderating effect of 1) an accurate conceptualisation of FMS; 2) instructor type (schoolteacher or FMS specialist); and 3) use of single or multi-component interventions. The outcomes from this study (chapter 3) establish the importance of the inclusion of FMS activities in the proposed playground intervention (chapter 8).

Table 1.1 Thesis aims and objectives

Aim 1	Synthesise and meta-analyse the current literature on the effectiveness of FMS interventions at improving daily levels of MVPA	Chapter 3
Objective 1	Perform a systematic review and meta-analysis examining the effectiveness of FMS interventions aimed at increasing physical activity through development of FMS competency in primary school children.	
Aim 2	Identify areas of the playground that promote higher engagement of primary school children in MVPA. Explore the effect of environmental and contextual characteristics on the proportion of break-time MVPA episodes.	Chapter 4
Objective 2	Using systematic observation – measure the number of MVPA episodes on the playground during break-times. Examine the contexts (e.g., supervision) in which these activities occur and identify environmental characteristics (area size, equipment type, surface) of school playground areas which promote the highest levels of MVPA	
Aim 3	Determine primary school children's break-time enjoyment levels of various playground activities. Explore adult and child perceptions of break-time enjoyment levels.	Chapter 5
Objective 3	Using the lunchtime enjoyment of activity and play questionnaire (LEAP), examine the enjoyment levels of a variety of physical activities that primary school children engage in during break-times. Establish gender and age differences in enjoyment levels and establish if differences between genders are different in younger (KS1) and older (KS2) children (interaction).	
Aim 4	Determine primary school playground users (staff and pupil) perceptions of the current playground environment.	Chapter 6
Objective 4	Qualitatively explore staff and pupils perceived barriers and facilitators to a physically active playground through the use of focus groups and interviews. Gain a deeper understanding of why children engage in, like and dislike specific areas and activities of the playground.	
Aim 5	Present a proposed primary school playground intervention focussing on enhancing FMS competence and MVPA levels in primary school children.	Chapter 7 & 8
Objective 5	Synthesise the findings from each thesis chapter and identify key components to a primary school playground intervention. Present a multi-level playground intervention targeting each component of the socio-ecological model. The proposed intervention will be underpinned by outcomes from previous exploratory chapters in this thesis with key findings from each chapter cross referenced to the appropriate intervention component	

1.8 Summary of chapters

In study one (chapter 3) the use of meta-analysis added to the quality assessment (risk of bias). The meta-regression will allow us to elaborate on the effectiveness of the interventions and to identify the higher quality studies and the intervention characteristics which resulted in more positive physical activity outcomes. Study two (chapter 4) used observers trained in direct, systematic observation methods to identify areas of the primary school playground which promoted higher amount of MVPA. Hotspots for MVPA were produced using the MVPA counts to identify the areas, and their unique characteristics which promote higher levels of activity. Furthermore, contextual characteristics were explored to identify if the presence of playground supervisors, organised activities and provision of playground equipment (e.g., balls, scooters, skipping ropes) had any influence over the levels of break-time MVPA levels. The outcomes from this study will inform the intervention development and identify potential playground areas that would benefit from future interventions, whilst ensuring interventions do not remove current physical activity facilitators.

The next two chapters (chapter 5 and chapter 6) in this thesis explore the enjoyment of current playground activities, the satisfaction with the current playground environment and the barriers and facilitators to a physical active school playground. The enjoyment of playground activities (chapter 5) during break-times were identified using a Likert type questionnaire for pupils and staff (The Lunchtime Enjoyment of Activities and Play: LEAP Hyndman, Telford, Finch et al. 2013). The justification for including this study was to offer some narrative to why children engage, like and dislike particular areas of the school playground more than others during break and lunch-times (areas that were identified in chapter 4). Chapter 6 used a mixture of focus group activities (children), interviews and questionnaires (staff) to explore the current playground perceptions from the main users of this environment during break and lunch-times. The use of thematic analysis techniques allowed for current playground dynamics (boundaries, rules, safety, behaviour management and staff engagement) to be explored and inform the proposed playground intervention (Chapter 8).

Chapter 7 (synthesis) and chapter 8 (intervention proposal) were included to reflect on the previous study outcomes to inform the development and optimisation of the playground intervention. Chapter 7 will include a synthesis of study findings, practical applications and recommendations for future research prior to the introduction of the intervention proposal (Chapter 8). Chapter 8, which is informed by findings of all the chapters in this thesis highlights how each component of the designed intervention is linked to the outcomes from the previous chapters. This stage of development, presented at this Chapter allowed further consultation with key stakeholders (patient and public involvement) regarding perceived feasibility, acceptability and implementation in the proposed intervention, the recruitment and the selection strategy, which all informed the future delivery and piloting of the intervention.

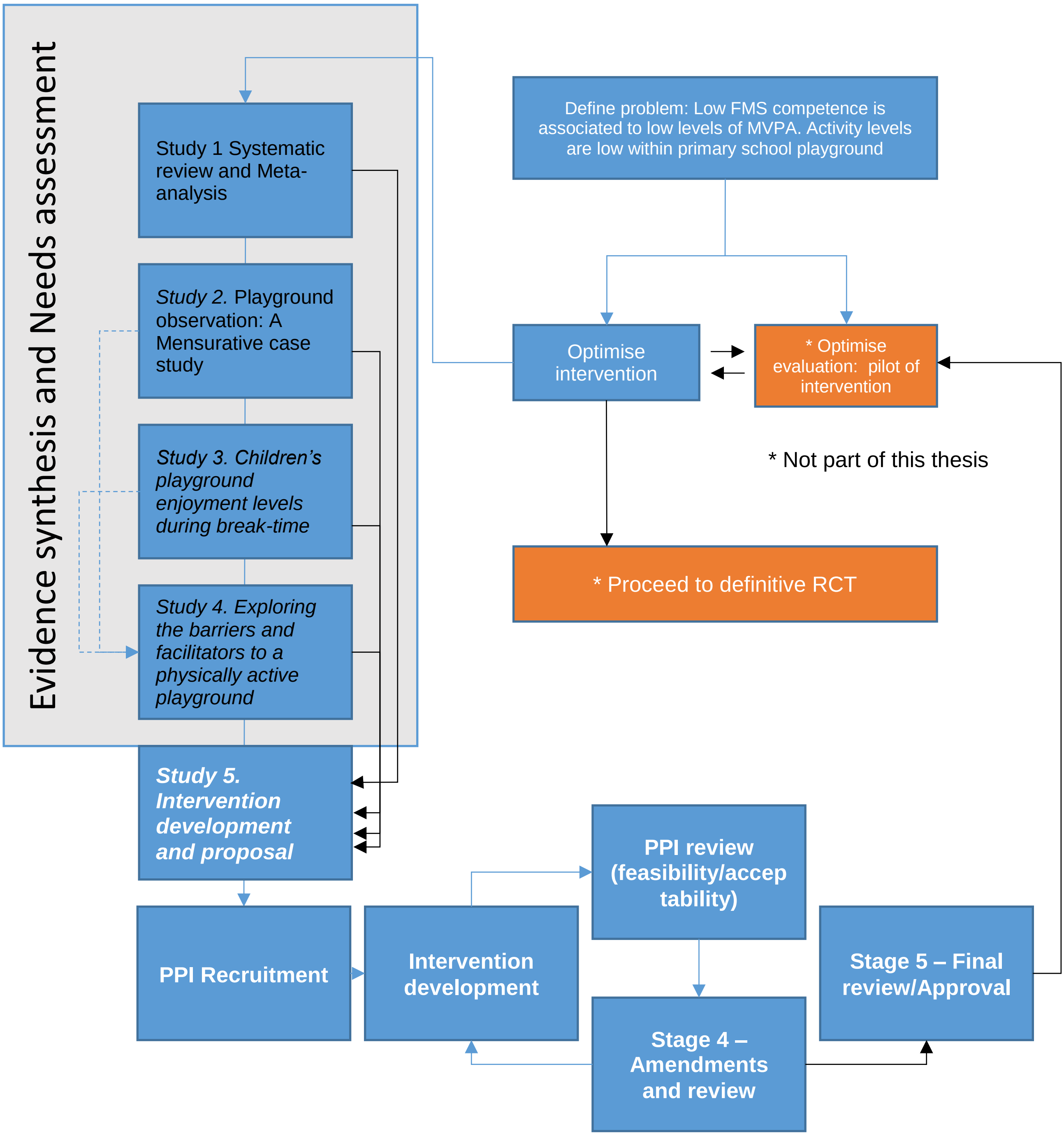


Figure 1.1. PhD study framework: Needs analysis (van Sluijs and Kriemler 2016) aligned with the MRC framework (2008) for developing and evaluating complex interventions

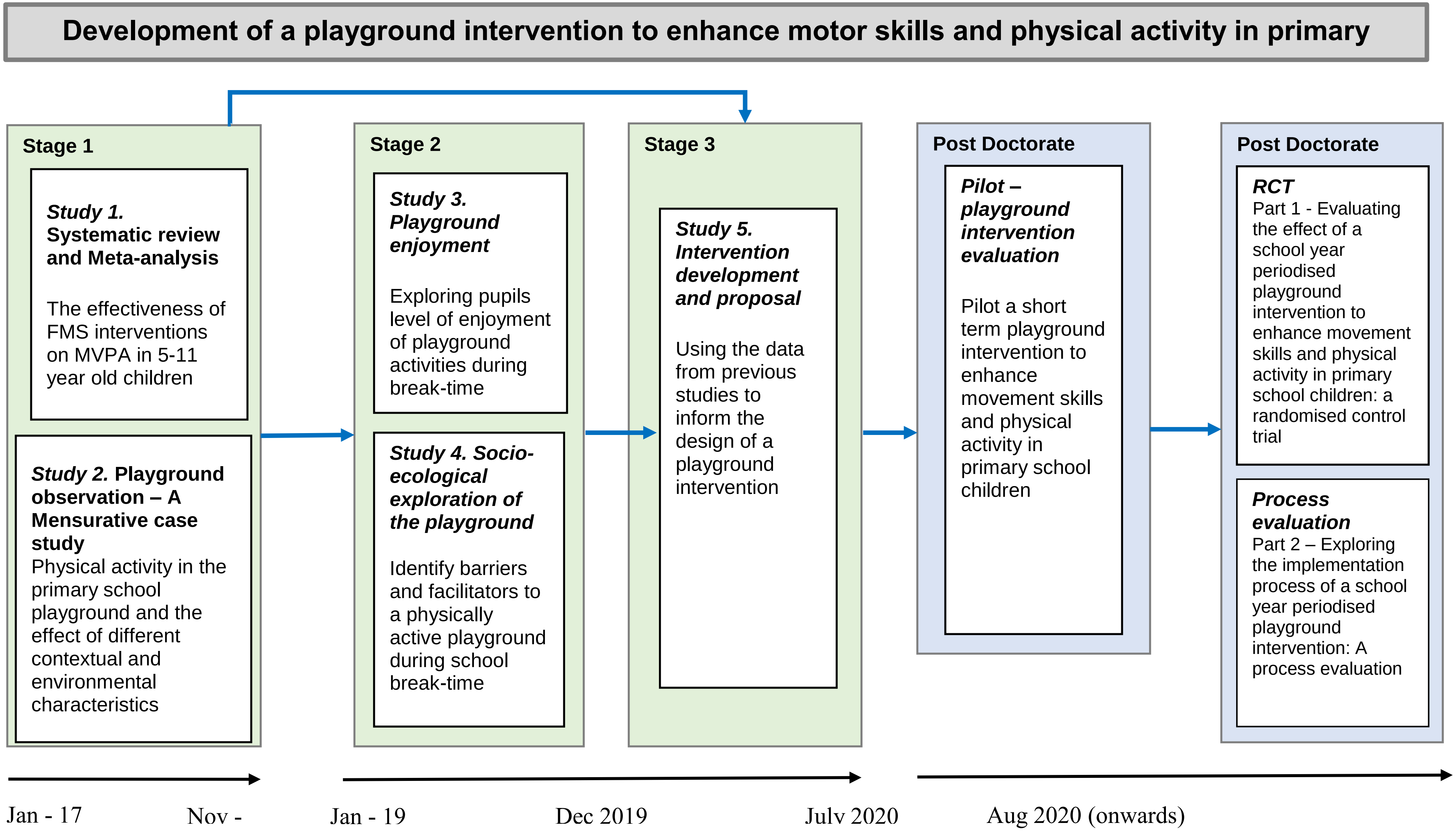


Figure 1.2 PhD study framework including proposal for Post-doc activities

CHAPTER 2: LITERATURE REVIEW

2.1 Overview

This chapter will provide a critical review of the literature regarding physical activity in children. A combination of experimental, cross-sectional and longitudinal research will be explored to present and discuss the current evidence surrounding the three overarching topics related to this thesis.

Physical activity in children:

- The role of physical activity on children's health and well-being
- Play, active play and physical activity
- Physical activity participation rates, and rates of decline
- Measurement of physical activity in children
- Correlates of physical activity in children

Fundamental movement skills:

- FMS overview and definitions
- Measurement of FMS
- Effectiveness of FMS interventions on FMS competency
- Importance of FMS and FMS association with physical activity

An ecological approach to school based physical activity:

- School based physical activity and health promotion
- Physical education
- Break-time and the primary school playground
- Socio-ecological model (Davison and Birch 2001)

2.2 Physical activity in children

2.2.1 The role of physical activity on children's health and well-being

In the UK, data from the national child measurement programme (NCMP) suggest more than 20% of 4 to 5 year old children and over 30% of 10 to 11 year old children are overweight or obese (NCMP 2019). In the Tees Valley, there has been a steady increase in the percentage of children classified as overweight or obese over the last three years with 25% of reception children and 40% of year six children now classified as overweight or obese (NCMP 2019).

The promotion of physical activity is a key part of national (UK DoH 2016: Childhood obesity: a plan for action) and international strategies (WHO 2017: Commission on ending childhood obesity) on targeting childhood obesity due to an increase in physical activity resulting in an increased energy expenditure. However, physical activity has important health benefits beyond desirable changes in bodyweight. For example, Ekelund et al. (2007) analysed cross-sectional data from the European Youth Heart Study (EYHS) to identify independent associations of physical activity with individual and clustered metabolic risk factors. Data from n=1092, 9 to 10 year olds from Denmark, Estonia and Portugal, including anthropometric, biochemical and objectively measured physical activity data (collected using accelerometers) were analysed. The findings highlighted that not only was physical activity inversely associated to indicators of independent (insulin resistance, hyperglycaemia, hyperlipidaemia) and clustered (z score; waist circumference, hypertension, hyperglycaemia, insulin resistance, hyperlipidaemia) metabolic risk factors, but subcomponents of physical activity; particularly time spent in MPA which was also significantly inversely associated with the same risk factors (Ekelund et al. 2007).

Furthermore, MVPA showed significant negative associations with body fatness (sum of skinfolds) (Ekelund et al. 2007). Analysis from a smaller sample taken from the same EYHS data, found that body fatness was negatively associated with VPA but not MPA (Ruiz, Rizzo, Hurtig-Wennlöf et al. 2006). The difference in sample characteristics and sample size might explain some of the differences noted here. Although the studies analysing the EYHS data are cross sectional, there are a sufficient numbers of EYHS studies to be confident of the inverse relationship between a higher physical activity level, weight classifications and markers of poor cardio-metabolic health (Ekelund, Sardinha, Anderson 2004; Anderson, Harro, Sardinha 2006; Ruiz et al. 2006; Ekelund et al. 2007). Furthermore, a recent, large systematic review of experimental (controlled trials) and observational (cross sectional and longitudinal) studies from 31 countries found predominantly favourable effects of total physical activity on cardio-metabolic risk factors, bone health, and physical fitness (Poitras, Gray, Borghese et al. 2016) whilst participation in MVPA (upper quartiles) has been found to have protective effects on insulin resistance (Peplies, Börnhorst, Günther et al. 2016). The evidence supporting the cardio-protective and other physical benefits (reduced adiposity and improved bone health) of childhood participation in physical activity is substantial (Strong et al. 2005; Janssen and Le Blanc 2010). However, there are additional benefits of physical activity participation beyond physical health protection that are important to children's overall health and well-being.

'*Mens Sana in Corpore Sano' (a sound mind in a sound body)* – Juvenal, 2nd century AD

Parfitt and Eston (2005) assessed children's psychological well-being (depression, anxiety and global self-esteem) and its association with physical activity levels. Physical activity levels were negatively associated with self-reported levels of depression (r = -0.60) and anxiety (r = -0.48), and positively associated with self-esteem (r = 0.66). Furthermore, the authors noted significant reduction in depression and significant improvements in self-esteem with increasing activity levels (Parfitt and Eston 2005) with children who accumulated more than 12,000 steps per day having more positive outcomes. Furthermore, a recent review of systematic reviews demonstrated a growth in the evidence highlighting links between physical activity and mental health in children, when mental health is restricted to the outcomes of depression, anxiety, self-esteem and cognitive functioning (Biddle et al. 2019).

However, variables such as social interaction, the method of physical activity and the physical environment surrounding the children; could affect the relationship between physical activity levels and the psychological well-being of children (Parfitt and Eston 2005).

2.2.2 Play, active play and physical activity

'Play' and 'active play' have an important role in the early phases of cognitive, physical, social and emotional development of a child (Ginsburg 2007) and allows children to explore new environments, develop relationships and discover their identity (Jones and Okely 2011). Play is integral in supporting children in the integration and exploration of the school environment (Ginsburg 2007), and physical activity through active play has been found to enhance children's readiness to learn (Coolahan, Fantuzzo, Mendez and McDermott 2000). Play is recognised as a basic human right of every child (Office of the United Nations 1989) and is an essential part of childhood and is essential for human development (Ginsburg 2007). Play can be defined as *"behaviours which are freely chosen, personally directed, intrinsically motivated, spontaneous and pleasurable"* (Brockman, Fox and Jago 2011). However, there are many different forms of play which are largely influenced by the context (situation specific) and environment (indoors, outdoors, available space, provision of equipment).

Active play, for example, is *'a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner'* (Truelove, Vanderloo, Tucker 2017). It has been suggested that creativity, conflict resolution, social skills, conquering fears and resilience are all key developments that more active forms of play contribute to (Brockman et al. 2011). However, the aforementioned definition applies more accurately to outdoor play, particularly when considering the freely chosen, unstructured nature of children's play during school break-times in the school playground environment.

However despite evidence suggesting 'active play' has a substantial contribution to physical activity (O'Dwyer et al. 2012) and MVPA levels (Engelen et al. 2013) the amount of unstructured free play time children take part in has decreased by an estimated 25% between

1981 and 1997 (Hofferth and Sandberg 2001), seemingly driven by an increase in access to more passive, sedentary activities such as television watching, playing computer games, and accessing social media platforms on the internet (Crane, Naylor and Temple 2018). Furthermore, a recent systematic review of active play interventions and their effect on physical activity and FMS competence highlighted that there was no significant effect of active play interventions on MVPA with a narrative to suggest a stronger likelihood of positive effects on total volume of physical activity. However, the authors identified a lack of studies (n=4) investigating the effect of active play on physical activity or FMS. As a consequence, the meta-analysis examining the pooled effect of active play interventions on MVPA consisted of only two studies, and despite the authors claim of homogeneity (issues with running a meta-analysis with only two studies) there was substantial difference in individual mean and standard deviations. An increase in high quality randomised controlled trials investigating the effect of active play interventions on physical activity and MVPA in children are needed (Johnstone et al. 2019). Furthermore, an assessment of the effect of a number of social, environmental and policy level determinants on interventions effectiveness will highlight important areas of focus.

Effective physical activity promotion is essential during childhood years in order to shape the physical activity behaviours in adulthood; improving physical and psychological well-being, and reducing the risk of cardiovascular disease. Despite this, there is a concern that children are not participating in sufficient levels of physical activity on a daily basis.

2.2.3 Physical activity participation and rates of decline

The UK DoH (2019) recently updated physical activity guidelines recommending children and young people to engage in MVPA for an average of 60 minutes per day across the week. In contrast to previous releases, the CMO report highlights that although all individuals should attempt to achieve the guideline amount of MVPA and “more is better”, there is in fact no absolute threshold, acknowledging that benefits can be realised below and above the recommendations (UK DoH 2019).

A recent study harmonised physical activity data; measured using the same accelerometer type (Actigraph), from 47,497 children and adolescents across Europe (Steene-Johannessen, Hansen, Dalene et al. 2020). Using the most recent physical activity guidelines (average ≥ 60 minutes of MVPA per day across the week) the authors identified that 29% (95%CI: 25% to 33%) of children (2 to 9.9 years of age) and 29% (25% to 32%) of adolescents (≥10 to 18 years of age) were sufficiently physically active (Steene-Johannessen et al. 2020). Ignoring some of the study limitations around demographic representation (i.e., weight status, ethnicity, gender) and possible variation in accelerometer epoch durations, the study also revealed that despite having the second highest prevalence rate in Europe, that 31% of UK children (21% to 40%), and 30% (27% to 32%) of UK adolescents were sufficiently active (Steene-Johannessen et al. 2020).

There is a slightly more positive report of physical activity levels from Sport England's Active Lives CYP survey (Sport England 2019). The Active Lives CYP survey report is released each December and gives an insight into the physical activity levels of children aged 5 to 16 in England during the previous academic year. The CYP second annual report (Sport England 2019) is the first assessment of children's activity levels following the change to the UK CMO physical activity guidelines. Sport England (2019) stated that 46.8% of children (an estimated 3.3 million children aged 5 to 16 years) in England in the 2018/19 academic year achieved an average of 60 minutes of MVPA per day. However, despite an increase of 3.6% on the previous year, more than half of all 5 to 16 year olds (53.2%) are still failing to reach the recommended level of physical activity and nearly a third of all children (29%) are achieving less than an average of 30 minutes a day of MVPA (Sport England 2019).

There was a similar result across all school year groups, however middle primary school years (years three to four) and late secondary school years report the lowest levels of physical activity nationally (43% and 41%, respectively) with a reduction of 10% from lower primary (5 to 7 years old) and middle primary school years (Sport England 2019). Furthermore, as a region, the percentage of children in the Tees Valley achieving the UK CMO physical activity recommendations falls as low as 34% (Sport England 2016).

Despite disparities in data collection methods (accelerometry and self-report), the recent findings from Sport England (2019) and Steene-Johannessen (2020) highlight the insufficient physical activity levels of European and UK children and adolescents. With so few (less than half) middle primary school children achieving the advocated amount of MVPA (Griffiths et al. 2013; Sport England 2019; Steene-Johannessen 2020), focus in the scientific literature has turned to the age at which participation in MVPA begins to decline.

Until recently, it was generally accepted that the most marked decline in MVPA occurs during adolescence (Corder, van Sluuijs, Ekelund et al. 2010; Dumith, Gigante, Domingues et al. 2011; Jaakkola and Washington 2013; Corder, Sharp, Atkin et al. 2015). One notable contrast to this opinion is offered by Cooper, Goodman, Page et al. (2015) analysis of pooled accelerometry data from the International Children's Accelerometry Database (ICAD) (Cooper et al. 2015). Following entry into formal education (5 years old), MVPA begins to decline steadily and continues this decline throughout childhood and adolescence (Cooper et al. 2015). Despite issues surrounding study design (mainly cross sectional studies in younger age groups) and measurement differences (accelerometer wear location and cut points) in ICAD studies, the analysis of objectively measured physical activity from Cooper et al. (2015) contradicts the opinion of an adolescence onset of decline in MVPA (Reilly 2016). This is re-enforced by Steene-Johannessen et al. (2020) who established that the onset of age related lowering of physical activity become apparent at around 6 to 7 years of age.

Longitudinal data from the Iowa Bone Development Study (IBDS) (Kwon, Janz, Letuchy et al. 2015), which collected data from children born in the 1990's at regular time points between the ages of 5 and 19 years of age, found declines in MVPA across childhood and into adolescence. Additionally, objectively measured MVPA (accelerometers) taken from 7 year old children over an eight year period indicated that 61% and 62% of the sample (n=431; 50% Male) gradually declined from 7 years of age in male and female children, respectively (Farooq et al. 2017). These findings have important implications, as both males and females total physical activity and MVPA begin to decline much earlier in childhood than previously thought (Sallis et al. 2000; Hallal, Anderson, Bull et al., 2012; Corder et al., 2015; Reilly, 2016). Farooq et al. (2017) argues that given similar declines are observed in male and female children, a need to concentrate on 'high risk groups' is unnecessary, a view echoed by others in the field (Reilly, 2016). These findings are particular important for this thesis as data from Farooq et al. (2017) was collected from children in the north east of England.

Jago, Solomon-moore, Macdonald-Wallis et al. (2017) analysed accelerometry data from 1299 primary school children taken during year one and year four of primary school and identified a similar average decrease in total physical activity (accelerometer counts per minute) as the ICAD data and the IBDS data, for male and female children between the two time points. However, unlike previous longitudinal studies, Jago et al. (2017) suggested there to be a more marked MVPA decline in female (7 minutes; 11%) than male children (3 minutes; 4%) between the ages of 5 and 9 years old.

An increase in the aggregation of objectively measured physical activity using one standardised threshold for MVPA (accelerometer counts) with an increase in more longitudinal studies reporting changes in MVPA (Reilly 2016), particularly focussed on the transitional periods in school (reception to KS1; KS1 to KS2 and KS2 to KS3 onwards) would help to clarify any differences in the trajectories of MVPA levels between males and females.

Not all individuals follow the same trajectory of MVPA decline through childhood (Kwon et al. 2015; Farooq et al. 2017). Three distinct subgroups were evidenced in the IBDS; 1) stable MVPA across childhood and adolescence, 2) low and steadily declining MVPA, and 3) high initial MVPA with rapid decline (Kwon et al. 2015). More recent evidence from the Gateshead

Millennium Cohort study found subgroups with similar trajectories; 1) low and relatively stable/slow decline, 2) gradual decline from baseline, and 3) high initial MVPA but rapidly declining (Farooq et al. 2017). However, there was a marked difference in the presentation of a fourth trajectory identified by Farooq et al. (2017), as relatively high, and stable or increasing. It is not uncommon to see high physical activity baseline values, however, they often result in regression towards the mean (Dumith et al 2011). However, in the sample of the study from Farooq et al. (2017) the level of MVPA actually increased throughout childhood and adolescence.

Marked differences in the trajectories of MVPA across childhood and into adolescence make prevention challenging (Reilly 2016). Though the final subgroup mentioned in the Millennium cohort study was only 19% of a relatively small sample, understanding the characteristics, behaviours and lifestyles of these identified subgroups would help inform future policy and practice (Farooq et al. 2017).

Jago, Salway, Emm-Collinson et al. (2019a) identified that the rate of decline in MVPA levels between 6 and 11 years of age was 2.2 minutes per day for every year of age. However, the rate of decline increased for children who were classified as overweight or obese. Despite no difference in baseline (6 years old) MVPA levels between weight classification (Body max index; BMI), as children got older the difference in MVPA levels between healthy weight and overweight children and healthy and obese children increased by 1.7 minutes per day and 2 minutes per day respectively, for every year. It would be useful to establish if the subgroup trajectories established in the Gateshead Millennium Cohort Study exist in other samples/populations and what the environmental and cultural impacts on physical activity levels are in these population. Identifying and studying the determinants of physical activity, such as, the influence of movement skill competence on MVPA levels and physical activity participation, should be a pre-requisite to designing effective interventions (Trost, Owen, Bauman et al. 2002).

2.2.4 Measuring physical activity in children

Physical activity has been defined previously in this thesis (section 1.5; pg.8). However, to establish the energy cost of different activities, physical activity is categorised by the level of intensity, namely; light (LPA), moderate (MPA) and vigorous (VPA). Perpetually, the moderate and vigorous categories are combined to form moderate-to-vigorous physical activity (MVPA), characterising a threshold beyond which activity can be classified at least of moderate intensity. Although the terms remain the same for adults and children, the quantification of the intensity differs to reflect the higher resting metabolic rate (RMR) in children and the disproportionately higher energy expenditure for physical activities per kilogram of body mass (Butte, Watson, Ridley et al. 2018).

Epidemiological studies most commonly measure the intensity, duration, and frequency of physical activity using either; self-report questionnaires, direct observation, wearable devices (e.g., pedometers, accelerometers, heart rate monitors), direct/indirect calorimetry or the doubly labelled water method (Ndahimana and Kim 2017). The outcomes from these measures can then be converted to energy expenditure (where not measured directly) using the adult (Ainsworth, Haskell, Herrmann et al. 2011) and youth (Butte et al. 2018) compendium for physical activities using the associated metabolic equivalents (METs). A MET, or MET_y to be more accurate for children and adolescents, are used to express the energy costs of physical activities as multiples of RMR (Ainsworth et al. 2011). An activity MET_y value of five would mean the energy expenditure for that activity is five times higher than the RMR (Butte et al. 2018). Although there is some disagreement in the literature, it is generally accepted that values below three MET_y can be classified as light intensity, and values between three and six MET_y considered moderate (WHO 2010). Therefore, values above three MET_y can be considered as MVPA. A child's physical activity energy expenditure for a given activity can then be calculated by multiplying the MET_y value by the RMR average of 1.9 $kcal \cdot kg^{-1} \cdot hr^{-1}$ (Butte et al. 2018).

In addition to calculating energy costs of different physical activity behaviours, accurate measurement and reporting of the quantity and intensity of physical activity is important for the assessment of compliance with the CMO guidelines, and to test the effectiveness of physical activity interventions (Butte et al. 2018). Physical activity is a complex construct (Butte et al. 2012) and in most cases, the environment in which physical activity occurs might decide/restrict some of the methods mentioned. For example, the double labelled water method and indirect calorimetry is used more as a gold standard method by which new measurement methods are validated (Trost 2007). However, it requires expensive equipment and complex methods that are impractical when collecting physical activity data in the field (Trost 2007). Additional considerations such as; labour intensity (direct observation), validity and reliability in reported outcomes (self-report questionnaires and diaries), suitability to the activities being recorded, and participant wear compliance (pedometers and accelerometers) may result in a combination of methods applied. For example, by combining accelerometry, observation and physical activity diaries there is an opportunity to capture the wider context in which physical activity occurs (Ndahimana and Kim 2017). Understanding the advantages and disadvantages to each of the aforementioned measurement methods (cost, accuracy, accessibility) is essential as there is not one single method that can be described as optimal in every situation (Trost 2007; McKenzie 2016), Therefore, a comprehensive assessment should be completed prior to the decision to choose one method over another (Ndahimana and Kim 2017).

Motion sensing technology, predominantly accelerometers has become the most common method of measuring physical activity in children (Trost 2007). Accelerometers provide quantitative information regarding the accelerations of body segments in one (uni-axial) or more planes (tri-axial) of movement (about more than one axis of rotation), measurable over variable periods of time (hours, days, weeks). Accelerometers, therefore, are able to quantify the intensity, frequency and duration of physical activity by collecting accelerations over a set period of time called an ‘epoch’ (usually between one second to one minute) and then summing these data and storing them as counts. These counts are then quantified using specific age related intensity cut points for LPA, MPA and VPA (Freedson, Pober, Janz 2005; Evenson, Catellier, Gill et al. 2008; Chandler, Brazendale, Beets et al. 2016). A "cut point conundrum" and a contrast in end point reporting of outcomes (Trost 2007), for example; minutes of MVPA, percentage of time spent in each of the activity thresholds or the counts per minute for each activity threshold have made it difficult to compare research findings and intervene at the appropriate level in children's physical activity behaviours (Trost 2007). Furthermore, variation in the wear site (for example, hip or wrist) of accelerometers (and associated cut points) is also important to be able to accurately quantify the contribution from physical activities that may occur in a stationary position but through multiple planes (for example, cycling, throwing, stepping) (Duncan, Roscoe, Faghy et al. 2019).

Accelerometers continue to be used in small-to-medium sized experimental trials (Kriemler et al. 2011) but their use in studies with larger samples is often restricted due higher costs and practicality of use. However, using accelerometers in a subsample of participants in combination with direct observation methods is one approach that offers a number of important advantages. Direct observation allows researchers trained in systematic observation methods to accurately record moment to moment physical activity behaviours (intensity, type) whilst also recording contextual factors related to the physical activity behaviour, such as; environmental characteristics, the presence of others and equipment provision. Direct observation has been found to have good concurrent validity with accelerometry (McKenzie 2002) and its use in combination with other methods for quantifying physical activity levels should be encouraged (McKenzie 2016).

2.2.5 Correlates of physical activity in children

There have been a number of reviews of the correlates of physical activity in children and youth, presenting a range of potential correlates (Sallis et al. 2000; Van der Horst, Paw, Twisk and Van Mechelen 2007; Biddle, Atkin, Cavill and Foster 2011; Sterdt, Liersch and Walter

2014; Martins, Marques, Peralta, Palmeira 2017). Sallis et al. (2000) reviewed 102 articles from 52 separate studies from 1970 to 1998, followed by an update by Van Der Horst et al. (2007) with 57 additional papers from 1999 to 2005; including biological (age, sex), demographic (SES, parent education, ethnicity), psychological (self-perception), behavioural (TV watching), social (parent support) and physical (facilities/environment) correlates. These two valuable reviews highlighted subgroups that would benefit from targeted physical activity interventions with the non-modifiable variables, gender (female), and age (adolescent) found to be the groups most at risk for being inactive (Sallis et al. 2000; Van der Horst et al. 2007). Sterdt et al. (2014) identified similar gender and age related variables from a systematic review of review studies, with females and older children/adolescents consistently associated to lower levels of physical activity.

Although previous reviews (Sallis et al. 2000; Van der Horst 2007) found positive associations linking SES and weight status (BMI) to sedentary behaviour, there was insufficient evidence with only 33% of the studies supporting the associations between BMI, SES and physical activity. However, there are some limitations to the findings of the review articles. Firstly, publication bias associated with the under reporting of undesirable outcomes (Onishi and Furukawa 2014). For example studies which failed to find associations between BMI, SES and physical activity did not publish these outcomes and therefore these variables in the reviews had too few studies to make any conclusive association with physical activity levels. Further, Sallis et al. (2000) and Van Der Horst et al. (2007) main outcome was total physical activity, therefore potentially missing any association with the specific physical activity behaviours, for example; LPA, MPA and VPA (Van Der Horst et al. 2007). Finally, variables such as SES may have been measured using either an individual marker of SES (for example, parent education level or income level) or a combined number of variables (for example, using the index of multiple deprivation; IMD) leading to an inconsistency in the association between SES and physical activity levels.

Since publication of the aforementioned reviews (Sallis et al. 2000; Van der Horst et al. 2007; Sterdt et al. 2014), there has been a number of studies that have highlighted that physical activity levels vary by SES in adults (Marshall, Jones, Ainsworth et al. 2007) and children (Inchley, Currie, Todd et al. 2005; Brodersen, Steptoe, Boniface and Wardle 2007; Pereira, Reyes, Moura-Dos-Santos et al. 2020). Sport England's CYP survey (2019) highlighted a 12% difference in the percentage of children achieving the UK CMO physical activity guidelines, with 54% of children from more affluent families achieving an average of 60 minutes or more per day, compared to 42% from low affluent families. However, the relationship between SES and physical activity in children is complex, particularly as SES (measured using any of the independent or combined markers of SES) in this population is a measure of parent level SES. Therefore, SES may be better interpreted as a non-modifiable determinant of physical activity in children, as they are unable to influence many of the independent and combined markers of SES (Van Der Horst et al. 2007).

The association between total physical activity and BMI is also inconsistent (Biddle et al. 2011), however, this inconsistency in results has been explained by the different associations between physical activity outcomes. A recent cross-sectional study of primary school aged children from the south west of England (Wilkie, Standage, Gillinson et al. 2018) examined (using multi-level linear regression), the relationships between a number of potential correlates and LPA, MPA and VPA. Weight classification (BMI Z-score) was found to have a significant relationship with MPA and VPA levels but not LPA. Furthermore, a high BMI z-score was found to significantly reduce the odds (OR = 0.71) of meeting the previous MVPA guidelines (≥60 minutes a day). This study implies that there seems to be a threshold beyond which changes in body composition are observed (Abbott and Davies 2004), however, it is difficult to ascertain causality. Do children have a high BMI because they do not take part in enough physical activity at these higher thresholds (Wilkie et al. 2018), or do children with a high BMI z-score avoid MVPA because they find it difficult to take part in physical activity with higher intensities?

Active transport (walking, cycling, roller-skating, scootering), sports participation and self-efficacy have been found to have a strong positive relationship with MPA, VPA and meeting the guidelines for MVPA; but not with LPA (Wilkie et al. 2018). However, these variables each have their own relationships with BMI z-score, with a higher BMI related to lower-self efficacy and lower overall health related quality of life (Pinhas-Hamiel, Singer, Pilpel et al. 2005). Therefore, examining the nature of these interactions and the combined influence these interactions have on physical activity levels may be a better approach (Biddle et al. 2011).

The relationship between physical activity determinants becomes even more complex when considering the effect that the aforementioned variables have on children's FMS competence and the relationship between FMS competence and physical activity levels. The following section will discuss FMS and its relationship with physical activity in more detail.

2.3 Fundamental movement skills

2.3.1 A brief overview and definitions

Fundamental Movement Skills are observable patterns of movement behaviour which can be classified into stages of competence, such as; beginning, progressing, achieving and excelling (Gallahue et al. 2012, pg.446; Longmuir, Boyer, Lloyd et al. 2017). As mentioned previously, FMS can be categorised into three distinct movement categories; locomotive, object control/manipulative and stability skills. Gallahue et al. (2012) define the locomotor category as *"movements that involve a change in location of the body relative to a fixed point"*; object control/manipulative category as *"imparting force to, or receiving force from, objects"* and the stability category as "*any movement that places premium on gaining and maintaining ones equilibrium in relation to force of gravity"* (pg.49).

The term Fundamental Movement Skill aligns to the 'fundamental movement phase' of the life span (hour-glass) model of motor development (Figure 2.1) (Gallahue et al. 2012). This understanding of motor/movement development can be described as a continuous change in movement behaviour throughout the life cycle through the interactions of movement tasks, individual biology and environmental conditions (Gallahue et al. 2012). Early in the model, the reflexive and rudimentary movement phases are largely affected by hereditary factors. However, as an individual ages the sand in their hour glass (or their movement competence) is largely affected by individual, task and environment factors (constraints).

The theoretical foundations for motor development were laid between 1787 and 1928, a period labelled the precursor period (Clark and Whitall 1989) with much of the influence on developmental psychology stemming from the early baby biographers such as Tiedemann, Preyer and Shinn (1787-1900). Although these early insights into motor development highlighted the behaviours and sequences of behaviours that children go through early in life (Clark and Whitall 1989), they were very much concerned with the 'product' of development and the early reflexive and rudimentary movements, effected largely by genetic inheritance.

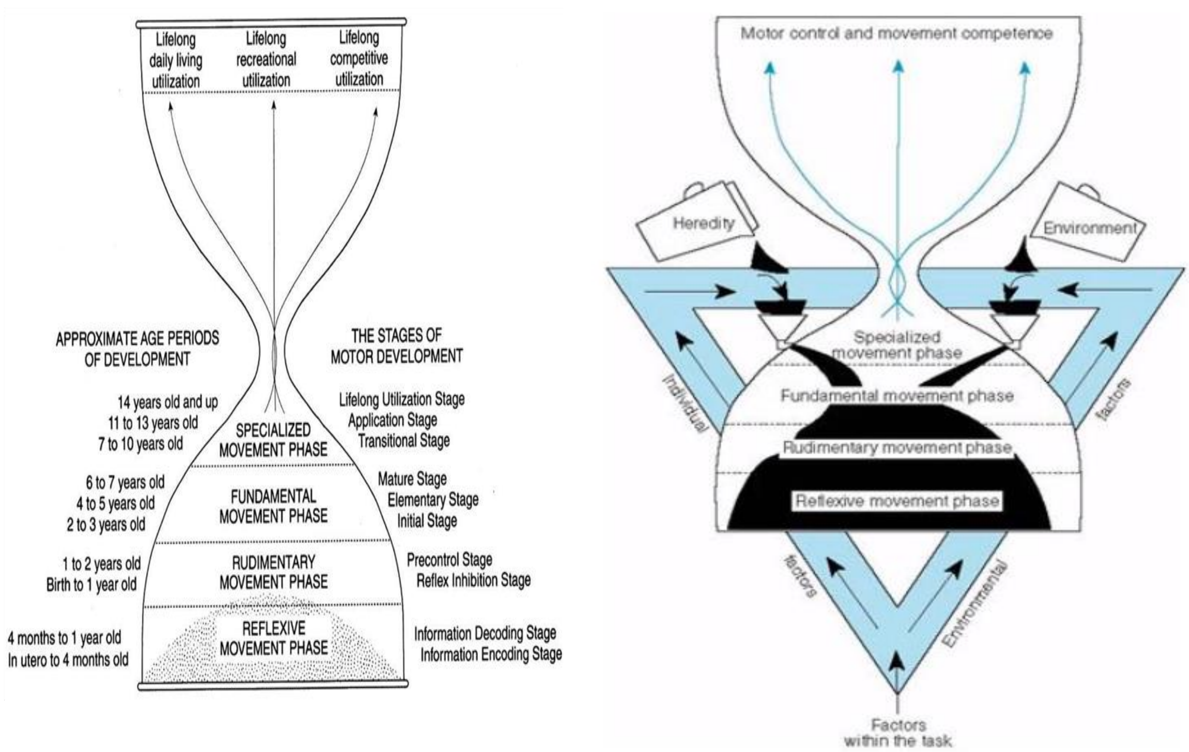


Figure 2.1. Gallahue et al. (2012) Hourglass/lifespan model of motor/movement development

In 1938, Monica Wild formed *"an attack on motor development…"* (Wild 1938) suggesting that *"much was already known about the genesis and growth of infants"* but how children of consecutive ages use their bodies when performing specific tasks (specifically throwing in this study) had yet to be studied. One of the main aims of Wild's study was to study the development (or 'process') of throwing behaviour in children from 2 to 12 years of age. Wild (1938) identified that the children progressed through distinct developmental phases when mastering the overhand throw, from simple upper body directional movements (in the early years) through to more complex, whole body coordinated movements (later in childhood).

Gallahue et al. (2012) identified that interest in the developmental sequence and the 'process' of children's skill acquisition has grown steadily since the early work of Wild (1938). Branta, Haubenstricker and Seefeldt (1984) highlighted that since the 1960's the inclination to measure movement using quantitative (product) measures has given way to an emphasis on qualitative assessment. Understanding the underlying mechanisms of development in movement skill competence, particularly gross skills, is the focus of many current researchers in the field of FMS (Clark and Metcalfe 2002).

Recent advances in FMS describe a set of skills (Table 2.1. for a list of FMS) that act as a foundation, serving as a base on which to build more complex skills needed to perform physically active pursuits in later life (Lloyd and Oliver 2012; Barnett et al. 2016a). It has been suggested that the development of FMS competence is an effective component, of which there are several, at contributing to the development of physical literacy (Barnett et al 2016a). Physical literacy is briefly defined as having:

> *"the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for maintaining purposeful physical pursuits/activities throughout the life course"* (Whitehead 2013; pg.29)

However, the physical literacy construct and the defining properties of physical literacy are debated (Edwards, Bryant, Keegan et al. 2017) and depend largely on taking a philosophical (Whitehead 2013) or practical (Balyi, Way and Higgs 2013) approach.

Irrespective of the debate surrounding the definition of physical literacy, there is an agreement that FMS are a key part in developing the physical components of physical literacy (Edwards et al. 2017) and offer a method of defining one's ability to move with poise, economy and confidence in a wide variety of physically challenging situations (Whitehead 2013). Understanding developments in movement competence include observing, understanding and explaining the process and product of movement patters over time (Haywood and Getchell 2009).

Table 2.1 Examples of FMS identified under the three main categories

Locomotor	Object manipulation/control	Stability
Walk	Throw	Bend
Run	Catch	Balance
Hop	Strike	Stretch
Skip	Kick	Turn
Bound	Dribble	Twist
Leap	Trap	Body rolling
Jump	Volley	Land/stop
Roll	Bounce	Extend/flex
Gallop	Push	Land
Slide	Pull	Hang
Dodge	Roll	Brace
Climbing	Carry	

Product-oriented assessments involve measuring the outcome of any number of FMS. For example, a product assessment of the 'jump' or 'bound' would score the height or distance, respectively, in cm. This method of assessment is important in terms of the assessment of an individual's 'performance' against their peers or normative data and to identify movement delays/disorders (Logan, Barnett, Goodway et al. 2017). As success in many sports is reliant on the fastest or most powerful, these assessments are also important in been able to establish a measure of FMS outcome which aligns with measures of strength and fitness. However, in earlier childhood, how high a child can jump or how fast they can run may not be as important as developing a proficient movement pattern. Furthermore, product assessments do little to inform future programs as they do not provide information on the proficiency of the skill (Branta, et al. 1984). Developing a proficient movement ability earlier in childhood can then be augmented by exploiting the maturational period for developments in strength (Lloyd and Oliver 2012) that would increase performance on many outcome, or product-oriented assessments. These phases of movements that a child goes through to perform the skill can be measured using a process assessment (see section 2.3.2. for more on the measurement of FMS).

A recent systematic review looked at how FMS were operationalised, conceptualised and measured (Logan, Ross, Chee et al. 2018). The authors of this article reviewed 124 peer reviewed full texts and extracted data to measure the number of studies that utilised a product or process oriented measure of movement competence. The majority of studies reported exclusive use of a process-oriented measure (n=98, 79%). This is not surprising, as the authors suggest, during this period much of the contemporary research favoured the use of process-oriented assessment (Barnett, Hinkley, Okely et al. 2012; Hardy, Reinten-Reynolds, Espinel et al. 2012; Foweather, Knowles, Ridgers et al. 2014). With that said, a number of studies (n=23, 19%) used a product-oriented method of measuring FMS, with only 5% of studies (n=6) using combination of product and process-oriented methods (Logan et al. 2018). However, to get a more comprehensive understanding of movement skill competence, researchers suggest using a measurement battery that incorporates both process and product-oriented assessment of FMS (Logan et al. 2017). Such an assessment will potentially provide researchers with a measure that captures multiple salient descriptors of FMS (Logan et al. 2017) (see section 2.3.3 for more on measurement of FMS) whilst also being able to examine their relationship with many performance outcomes (fitness, strength etc.).

In their systematic review, Logan et al. (2018) scored each FMS study against a number of criteria with the aim of being able to provide an operational definition of FMS. The criteria used were: 1) inclusion of a statement that suggests FMS are the "building blocks" (or similar terminology) of more advanced, complex movements required to participate in games, sports or other context specific physical activity, 2) inclusion of a statement that provides specific categories of skills that compose FMS such as object control, locomotor, or stability skills, and 3) provide at least one specific example of FMS (i.e. running, jumping, throwing etc.). The presence of each quality criterion was scored (0 = not present, 1 = present) and summed to give a total quality score (0-3) with nearly 50% of the articles reviewed scoring a 1 or below. This demonstrates that a large proportion of the contemporary literature (2000-2015) failed to give an adequate definition of their interpretation of FMS. These results would somewhat support the earlier criticisms of Almond (2014); and Pot and van Hilvoorde (2014) and highlight a need for clarity in communication from researchers examining FMS (Logan et al. 2018).

Though there has been an increased interest from researchers in the field of FMS, the associations and the context in which they are discussed have not always been applauded. Almond (2014) were concerned that the concept of FMS and its relationship to physical literacy have been adopted uncritically without consideration for its suitability or relevance. It should be reinforced that FMS and physical literacy are not synonymous. However, the subgroups of FMS (locomotor, object manipulation and stability) practiced and developed in a variety of settings may play a broader role, among other methods, in developing the physical competence aspect of physical literacy (Edwards et al. 2017).

Barnett et al. (2016a) have responded to several of the recent criticisms of FMS (Almond 2014; Pot and van Hilvoorde 2014). A key criticism of Almond (2014) was that FMS are not all fundamental and that skill transfer is limited. Barnett and colleagues argue that every one of the FMS domains should be considered ‘fundamental’ and it is the context that these are delivered and the populations’ skill level that would emphasise a need to concentrate on one or the other. For example, an increase in balance and stability is brought about through enhanced neuro-muscular integration of where the body is in space during a task (Rudd, Barnett, Butson, et al. 2015). The implication is that during dynamic actions for example, postural control acts as a significant constraint on successful performance (Davids, Bennett, Kingsbury et al. 2000). However, postural control serves the dual purpose of stability and orientation, enabling the body to achieve or restore a specific state of balance between the body and the environment (Horak 2006).

Likewise, the underlying attributes required for an advanced object manipulation skill, such as in a throwing/kicking technique (dynamic balance, optimal timing of relative timing of joint interactions, inter/intra muscular coordination and optimal transfer of energy through the kinetic chain) (Barnett et al 2016a) have broader applicability to mastery of other activities (running, swimming, climbing). Though stability skills have previously been contested as FMS (Butterfield and Loovis 1993); Rudd et al. (2017a) argued that accelerated learning of stability skills are important in their own right and support the development of more complex movement skills without hindering the development of locomotor skills or general coordination.

2.3.2 Measurement of Fundamental Movement Skills

There are a variety of measurement tools used to assess FMS in children (See Table 2.2 for a summary of measurement tools). However, because many of the assessments used in research were originally developed to identify development delay (for example, all versions of the MABC, TGMD, BOT) they may not accurately discriminate levels of skilfulness in typically developing children (Logan et al. 2017). This is not to disregard their usefulness for clinical purposes (St John and Cairney 2020), but rather highlight their limitation when working to establish a child’s holistic movement competency. For example, Bryant, Duncan, Birch and James (2016) assessed FMS as part of an evaluation of a six week physical activity intervention and had to exclude children at baseline as they were already scored at mastery level and therefore had no room for improvement. Furthermore, the purpose of some of the measures (MABC) is to establish general movement ability, inclusive of fine and gross movement skills, and may therefore be less sensitive in the measurement of FMS.

Many of the FMS testing batteries in Table 2.2 assess the performance of discrete skills in isolation (MABC, TGMD) (Tyler, Foweather, Mackintosh, and Stratton 2018) without taking into account their transferability to more complex, multi-skill activities; and the effect of individual and environmental constraints on the FMS outcomes (Tyler et al. 2018). Whilst this allows for a controlled assessment of individual FMS in isolation, it can be very time consuming (Tyler et al. 2018) and may not be sensitive enough to determine how exactly movement competence; inclusive of movement fluency, rhythm, and timing (Logan et al. 2017) relates to secondary outcomes; such as physical activity and physical literacy. More recently, movement skill assessments which capture a more holistic assessment of movement competence have been developed (Longmuir et al. 2017; Tyler et al. 2018)

Many of the studies on this topic present the FMS test batteries used, but rarely consider the influence that the differences in methodological approach may have on the outcome measure (Holfelder and Schott 2014). For example, differences in the specific skills measured, whether they use a process oriented, product oriented or combined scoring method, the level of skill instruction, the measurement environment (Logan et al. 2011), and the balance between FMS domains; may all have mediating effects on the outcome of the assessment. Consideration should also be paid to the components of FMS and their individual associations with different types of activities.

A child that excels in cross country running is likely to score very highly on a skills battery focussing on locomotor skills testing. Without consideration for the predominant physical activities and sports (running, football, gymnastics) children take part in, in relation to the skills assessed during FMS measurement, it would be hard to establish a holistic assessment of movement competence. For example, a child with an advanced tennis game, is likely to score higher (using total FMS score) on the TGMD-3 compared with the TGMD-2 due to higher number of object control criteria contributing to the total score (54 out of 100) compared to the TGMD-2 (48 out of 100). Therefore, Rudd, Butson, Barnett et al. (2016) suggest a more appropriate method may be the use of a wider range of testing batteries. Using a range of testing batteries that serve the dual purpose of an accurate assessment of discrete FMS (throwing, kicking, catching) whilst simultaneously assessing holistic movement competence (combination of skills in sequence (Such as the Canadian agility and movement skills assessment (CAMSA; Longmuir et al. 2017) and the Dragon challenge (DC; Tyler et al. 2018)) would enhance the understanding of the complex relationship between FMS competence and health.

Finally, Barnett, van Beurden, Morgan et al. (2009) highlight that due to the subjective nature of FMS measurement, studies should report their intra and inter-observer reliability for total FMS and at category level (i.e., locomotion, object control, stability). Some skills are more problematic to assess and therefore result in poorer reliability during assessment, leading to under/over estimations in establishing a relationship between FMS and secondary outcomes (Barnett et al. 2009).

Table 2.2. Frequently used measurement inventories in movement competence studies

Name	Year developed	Purpose	Product, Process or Combined	Age group (yrs:mth)
Movement ABC; ABC-2	1992; 2007	Identify movement impairments	Product	4:0 – 12:0
TGMD-1; TGMD-2; TGMD-3	1985; 2000	Identify developmental delay	Process	3:0-10:0
KTK	1974; 2007	Screening for children suffering from brain damage or learning disturbances	Product	5:0-14:0
PDMS-2	2000	Movement assessment for children with disabilities	Product	0:0-6:11
BOT-1; BOT-2	1978: 2005	Identify deficits of movement coordination	Product	4:0-21:0
MMT	2004	Detection of attention deficit disorder		5:0-6:11
CMSP	2009	Assessment of movement skills in preschool children	Process	3:0-5:0
CAMSA	2015	Dynamic assessment of FMS execution and evaluation of simple and complex movement capabilities in children	Combined	8:0-12:00
Get Skilled; Get Active	2000	Teaching and evaluation of FMS for primary school students	Process	5:0-11:0 (K-6)
FMS test package (EUROFIT)	1988	Evaluation of physical fitness of European school children	Product	6:0-18:0
Dragon challenge (DC)	2018	Dynamic assessment of fundamental, complex and combined movement skills	Combined	10:0-14:0
Start to Move: Movement assessment Tool (MAT)	2017	An application based assessment to help primary school teachers measure, record and track FMS	Process	4:0-7:0

Abbreviations: ABC = Assessment Battery for Children; BOT = Bruininks-Oseretsky Test; CAMSA = Canadian Agility and Movement Skill Assessment; CMSP = CHAMPS Motor Skills Protocol; KTK = KörperkoordinationsTest Für Kinder; MMT = Maastrichtse Motoriektest; PDMS = Peabody Developmental Motor Scales; TGMD = Test of Gross Motor Development

2.3.3 Effectiveness of FMS interventions on FMS competency

Evidence indicates that children should be proficient in most, if not all FMS by 6 years of age (Gallahue, Ozmun and Goodway 2012). Though in reality, as little as 11% of 12 to 13 year olds demonstrate mastery or near mastery of FMS (O'Brien, Belton & Issartel, 2016). O'Brien et al. (2016) believe that mastery of FMS are essential in progressing on to more advanced skills.

Tompsett, Sanders, Taylor and Cobley (2017) conducted a systematic review to explore and identify FMS intervention characteristics that could provide an area of increased focus that would be beneficial on physiological, psychological, and behavioural outcomes in children and adolescents. Following a review of 29 studies, the authors concluded that FMS interventions that encourage psychological autonomy were the most efficacious on FMS and physical activity outcomes. Despite no effect of FMS interventions on weight status, strength or flexibility, Tompsett et al. (2017) highlighted that 93% of included studies reported positive influences of FMS interventions on FMS outcomes. However, the inclusion criteria for this review was very broad, including children 5 to 18 years old, studies with a focus on overweight/obese children and children with developmental delay/disorders; each of which (age, weight status, development delay) has strong moderating effects on FMS proficiency (Barnett et al. 2016b). Moreover, their selection criteria was inclusive of single group studies (i.e. no control group) which significantly denigrates the effectiveness of such interventions beyond what could be expected from no intervention (i.e., continuing with the usual PE curriculum).

Nonetheless, the findings that FMS interventions have a positive effect on FMS as an outcome are promising. Furthermore, Dudley, Okely, Pearson and Cotton (2011) systematic review presented a similar positive relationship between interventions with an FMS focus and FMS outcomes. Despite Dudely et al. (2011) having a predominantly pedagogical focus, the authors identified that direct instruction from teachers who have received sufficient and ongoing professional development in these methods were effective in increasing children's movement proficiency and physical activity levels. Although their study was inclusive of only four studies that measured FMS as an outcome, all four studies reported significant between group effects in favour of the intervention groups measured post-intervention. Furthermore, Dudley et al. (2011) reported positive outcomes on physical activity (n = 13 studies) and enjoyment of physical activity (n = 3 studies). However, what was unclear is whether each of the interventions identified in Dudley et al. had a focus on FMS. Tompsett et al. (2017) concluded, following their systematic review, that there is a vast array of FMS definitions and measurement tools which makes it difficult to determine a standardised FMS assessment. Findings from a recent systematic review of FMS measurement tools supports this statement, with 57 different skill assessment tools identified with an assessment of 33 unique movement skills across tools (Hulteen, Barnett, True et al. 2020).

Without a clear definition of what constitutes an FMS intervention during the selection of studies for a systematic review, there is a risk that a number of key studies may have been missed during searches or incorrectly excluded/included during selection. Furthermore, Tompsett et al. (2017) and Dudley et al. (2011) were inclusive of children from 5 to 18 years of age without any sub-group analysis or discussion on the variety of outcomes by age, and lacked a quantitative analysis of outcomes (i.e., a meta-analysis). Therefore, a recommendation for a qualitative synthesis and meta-analysis of studies which have explored the effectiveness of FMS interventions on FMS and physical activity outcomes in primary school age children is needed.

Rudd, Barnett, Farrow et al. (2017b) evaluated the effectiveness of an eight week gymnastics curriculum at developing movement competence in children with a much smaller age range (8 to 11 years old) than the aforementioned systematic reviews. Children's (n=113, 46% female) movement competence was assessed before and after the intervention using two separate assessments, one product and one process-oriented assessment method (TGMD-2 and KTK). The authors found a significant intervention by time interaction for total FMS and object control skills in younger children (under 8 years old). There were no isolated differences observed in locomotor skills for either age group. The authors concluded that a gymnastic curriculum is an effective method of increasing FMS in younger children. However, the control group showed significantly larger improvements compared to the intervention group in older children (10 to 11 year olds). This led the authors to infer that the PE/sports curriculum for upper primary school was more effective than the gymnastic intervention delivered, suggesting an importance of designing developmentally appropriate FMS interventions. Furthermore, the intervention group participated in the usual curriculum and the intervention activities, therefore suggesting a possibility that intervention activities had a harmful effect on older children's FMS development. However, the intervention and control group from this study were recruited from the same school and it is likely that the significantly higher FMS in the upper primary control group were a result of control group contamination (Magill, Knight, McCrone et al. 2019).

The idea that older primary school children have a more advanced comprehension of study participation (which is likely to affect contamination) was supported by a previous study which also found beneficial effects of a 16 week gymnastic curriculum compared to a usual PE curriculum on stability and object control skills in lower primary school children (8.1±1.1 years old), without hindering the development of locomotor skills and general movement coordination when compared to age matched controls from the same school (Rudd et al. 2017a). These findings are promising, however, they are from a single study, from one school with a high risk of contamination between groups.

A recent systematic review identified 18 articles that investigated the effectiveness of FMS interventions in 3 to 12 year old children (Engel et al. 2018) with 14/18 articles contributing data to a number of meta-analysis conducted for the various outcome measures identified by the authors. Eleven articles contributed data for a meta-analysis of FMS as an outcome with the authors identifying a small, significant improvement in overall FMS (SMD = 0.26; 95%CI 0.14 to 0.38; p = <0.0001) (Engel et al. 2018). Furthermore, of the studies that measured

MVPA as an outcome (n = 10), meta-analysis of the pooled data showed a small significant effect in favour of the intervention (SMD = 0.22; 95%CI 0.07 to 0.38; p = 0.005). These findings are important as it is the first pooled quantitative analysis of FMS and physical activity outcomes from FMS interventions. However, Engel et al. (2018) were unable to quantify the effect of FMS interventions on FMS proficiency or daily levels of MVPA in primary school aged children. The number of studies identified by the authors as measuring FMS in primary school children were insufficient for meta-analysis (n=2) and the MVPA effects presented by the authors are inclusive of both preschool and primary school age studies. Further, Engel et al. (2018) used a similar selection strategy to that of Tompsett et al. (2017) and grouped studies focussing on overweight populations with studies without a specific focus on weight status. Engel et al. (2018) conducted a meta-analysis of studies by using the standardised mean difference (SMD), which allows for studies varying in units of measurement to be analysed together. However, in addition to earlier criticisms of SMD (Gøtzsche, Hróbjartsson, Maric, Tendal 2007; Tendal, Higgins, Jüni et al. 2009), it does not account for study differences that are a result of the strong moderating effects of age and weight status on FMS and physical activity previously mentioned.

There have been a number of FMS interventions that have shown improvements in object control (Bardid, Lenoir, Huyben et al. 2017; Nathan, Sutherland, Beauchamp et al. 2017), locomotion (Bardid et al. 2017) and over all movement competence (for example, the gross motor quotient of the TGMD-2) (Duncan, Cunningham and Eyre 2017). However, Barnett et al. (2016b) suggests it is not as simple as improving object control or locomotor independently, as the dynamic balance, contralateral coordination and optimal inter-intra muscular coordination is developed they become transferrable across all components of skill development. This is an important consideration for future assessment and contextualising of FMS. FMS tend to be grouped into categories because it creates order and structure that can be easily categorised during assessment (locomotor, object control, balance). However, movement, particular in children is not structured or ordered (Bailey et al. 1995). As identified by Gallahue et al. (2012) ‘hour-glass’, and Clarke and Metcalfe’s’ (2002) ‘mountain of motor development’ metaphors, efficient movement is established through a complex interaction between our bodies and the environment. Future assessments of FMS should consider utilising assessments which capture these complexities to establish a more comprehensive assessment of FMS competence (Tyler et al. 2018).

It is accepted that interventions that target FMS development are capable of producing a sustained impact in movement skills (Lai, Costigan, Morgan 2014). However the limited detail regarding intervention characteristics (attendance, on-task time, program length, session duration, quality of instruction etc.) make it difficult to ascertain the most important aspects to a successful intervention (Morgan et al. 2013). Future interventions should report their components in greater details to aid interpretation from reviewers and practitioners (Hoffman, Glaszio, Boutron et al. 2014). Holdfelder and Schott (2014) found that locomotor skills were positively associated with physical actively levels suggesting that interventions that target locomotor skill component of FMS would lead to competence in this domain and a higher physical activity level. However, similar positive association have been reported for physical activity and object control skills (Barnett et al. 2011).

2.3.4 Importance of FMS in childhood and physical activity association

Experiences during early periods of development (between 4 and 10 years old) are exceptionally important in shaping the capacity of the brain as its ability to change in response to these experiences is strengthened by its heightened plasticity (Figure 2.2) (Levitt 2009). During earlier stages of development the brain forms more connections that it needs to function optimally and the lesser used connections are pruned away over time. Once a particular circuitry pattern becomes established, it is difficult for the effects of new and different experiences to alter that architecture (Hensch 2005). Furthermore, the eventual results are not likely to be as extensive if experienced later in life due to the effort required to establish new and enduring neural connections (National Scientific Council on the Developing Child 2007).

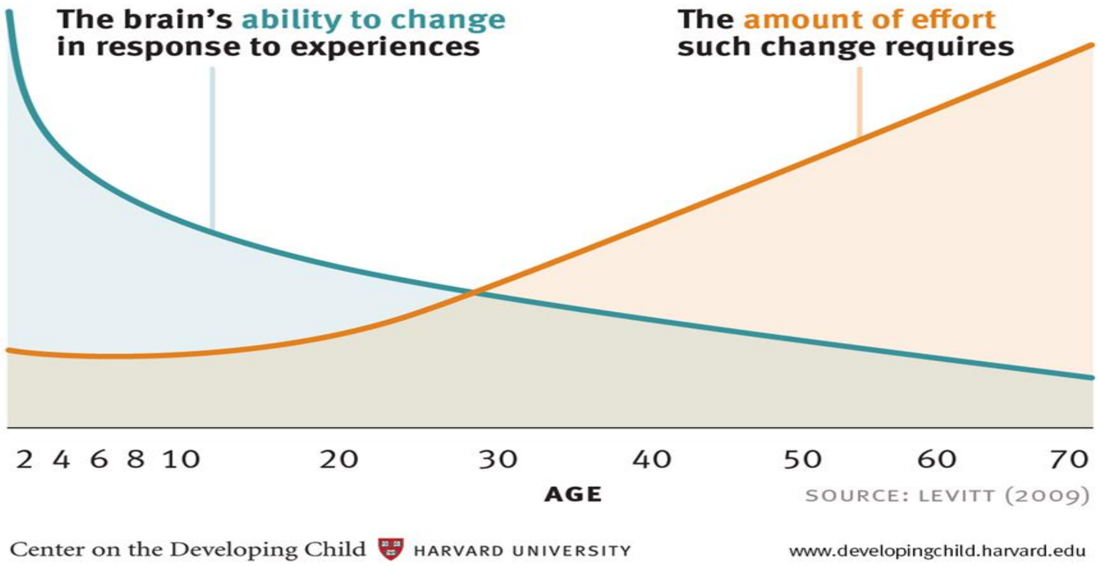


Figure 2.2 How early life experience can affect brain architecture.

Age is but one of a number of variables which has been shown to affect the rate at which a child learns and masters new movement skills. Children's gender (Laukkanen, Pesola, Havu, et al. 2014), weight status (overweight/obesity) (Lopes, Stodden, Bianchi et al. 2012; Gentier, D'Hondt, Shultz 2013) and SES (Woodard & Yun 2001) have also been attributed to the differing levels of FMS during childhood.

However, correlates of movement competence differ according to how it is operationalized (Barnett et al. 2016b). As children age, small-to-medium effects can be observed for all aspects of gross movement skills, with improvements for object control skills (r = 0.37; 95 %CI 0.29–0.35), locomotor skills (r = 0.44; 0.37–0.51) and stability skills (r = 0.34; 0.29–0.39) alike. Weight status (healthy), sex (male) and SES (higher) are only consistent correlates for certain aspects of movement competence (Barnett et al 2016b).

In the study of Barnett and colleagues (2016b), although the effect sizes are not presented due to insufficient data for meta-analysis, the authors found that being male was associated with higher object control skills; being female and between 5 and 8 years of age was associated with higher locomotor skills and a higher SES associated with higher locomotor and skill composite scores. Previous research has also found similar associations with overweight children, females and low SES recording lower scores for balance and stability, object control, and locomotor aspects of movement competence, respectively (Woodard and Yun 2001; Lopes et al. 2012; Laukkanen et al. 2014).

Fundamental movement skill competence, as mentioned previously, is considered an important prerequisite to physical activity participation (Barnett, Morgan, Van Beurden et al. 2011) with low levels of FMS competence considered a barrier to developing a physically active lifestyle (Lubans, Morgan, Cliff et al. 2010). Furthermore, FMS have been shown to have both positive and negative associations with physical activity and weight status, respectively (Barnett et al. 2016b). As such, the statutory guidance for the national curriculum for 5 to 11 year olds in England includes development and mastery of FMS in order to build and embed the skills across different sports and physical activities (UK DfE 2013).

Recent evidence has highlighted positive associations between physical activity and FMS competence through multiple stages in childhood (Hardy et al. 2012; Jaakkola and Washington 2013; Holdfelder and Schott 2014; Barnett et al. 2016b; Jones, Innerd, Giles and Azevedo 2020). Furthermore, there is evidence to suggest that the relationship between physical activity and FMS competence may be a reciprocal one (Barnett et al. 2011) with skill proficiency explaining 11% variance in MVPA; and MVPA explaining 12% in skill proficiency in youth (Barnett et al. 2011). However, the evidence for a reciprocal relationship between MVPA and specific subgroups of FMS should be interpreted with caution as this study relied solely on self-report measures of physical activity. In addition to the bias associated with self-report measures (Shephard 2003) the authors also relied on the adult compendium of physical activities, which may have resulted in incorrect estimations of MVPA.

Furthermore, the age of the children may play a large part in this relationship from a movement development perspective. Stodden et al. (2008) developed a conceptual model which suggested that in young children, being physically active is important to the development of movement competence; however, as children age this relationship reverses and movement competency then depicts the level of physical activity that children perform.

Although this suggests that the relationship between physical activity and movement skill competence is not entirely reciprocal (Barnett et al. 2016b) or at least not until middle to late childhood, it does highlight a window of opportunity where children may persist with the activity, despite the outcome (LeGear, Greyling, Sloan et al. 2012). In early childhood, this inflated perception of competence might be valuable to drive the acquisition of actual movement skill competence because children will continue to persist and engage in mastery attempts, to which they believe they are already skilled (Stodden et al. 2008). The outcome of this, as Stodden et al. (2008) proposes is a positive spiral of engagement in skill acquisition and physical activity that would strengthen over developmental time (Figure 2.3). Jones et al. (2020) systematic review found evidence to support Stodden et al. (2008) theory that physical activity drives the development of FMS in early childhood, however, were unable to comprehensively explore the mediating effect of perceived movement competence on the relationship between FMS and physical activity due to a lack of studies reporting perceived movement competence. However, it is likely that as cognitive abilities develop through childhood, there will be an increased accuracy in the child’s perception of movement competence (Stodden et al. 2008; Jones et al. 2020). Children who are less competent will have low perceived competence and follow a negative spiral of disengagement (Stodden et al. 2008).

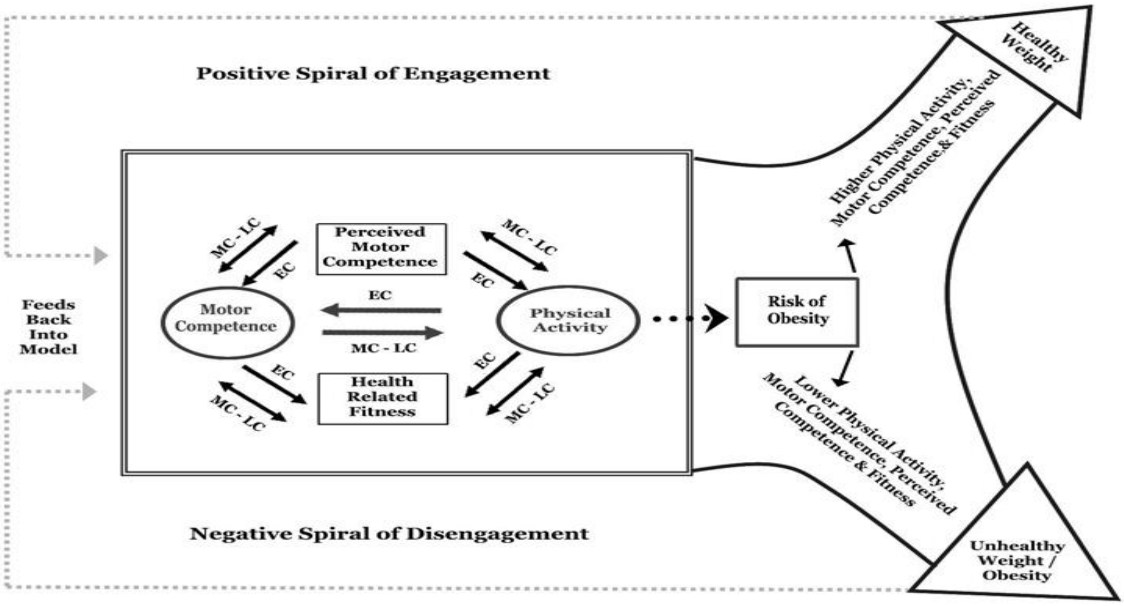


Figure 2.3 Stodden et al. (2008) Conceptual model - Developmental mechanism influencing physical activity trajectories of children. EC = Early Childhood, MC = Middle Childhood, LC=Late Childhood.

The aforementioned sections provide evidence for the association between FMS and physical activity levels. However, this relationship is complex and the effect of FMS competence on physical activity is likely determined by multiple factors.

Physical activity is a complex and multi-dimensional behaviour determined by numerous biological, psychological, sociocultural and environmental factors (Sterdt et al. 2014). Biddle et al. (2009) suggested that although there are a number of correlates which are likely to have small to moderate effects on physical activity levels, it is the interaction between these correlates that we should be more interested in pursuing. Ecological models of health (and physical activity) are one such method in considering a wide range of individual, social, environmental and policy level determinants which influence the health and well-being at a population level (Stokols 1992).

2.4 <u>Ecological approach to school based physical activity</u>

2.4.1 Socio-ecological Model

> *"To intervene effectively and to make informed judgements…health professionals should have an understanding of how health behaviours are adopted and sustained, and the motivation and constraining factors that influence, mediate and moderate change"* (Salmon and King 2010; in Jeffrey and Ball 2010, pg.187)

The socio-ecological model, originally developed by Brofenbrenner (1977) was adapted by Sallis et al (1998) who to focusses on the key environmental and policy agencies that have an active role in health and physical activity promotion. However, to date there is still little consideration of the individual desires, motivations and relationships that contribute to the success of large environmental and policy changes.

There is some suggestion that where some interventions fail in making any long term, sustainable changes to daily MVPA levels is a lack of consideration of the many interactive characteristics between individuals and their environment (Golden and Earp 2012). Socio-ecological models (SEM) provide a useful framework for understanding how interventions might target health behaviour change by recognising the individual, socio-cultural and environmental level facilitators and barriers (Salmon and King 2010).

Hyndman et al. (2016) suggest that to understand play and physical activity in children we need to consider the interaction between the intra-personal (individual), inter-personal (social), environmental and organisational/policy level influences. For example, implementing changes at an individual level by encouraging engagement in physically active pursuits during break-times will only work if appropriate environmental and policy level changes are also implemented at the school. Figure 2.4 displays the SEM of health (specific to school based interventions) and how each of these levels interact to create a sustained change in individual and population behaviours.

Many childhood physical activity interventions do not consider the multi-levels influences on children's behaviour during the intervention (Hyndman et al. 2016). However, Salmon and King (2010) suggested knowledge of each of these factors and their interaction is an important pre-requisite to guide school playground interventions.

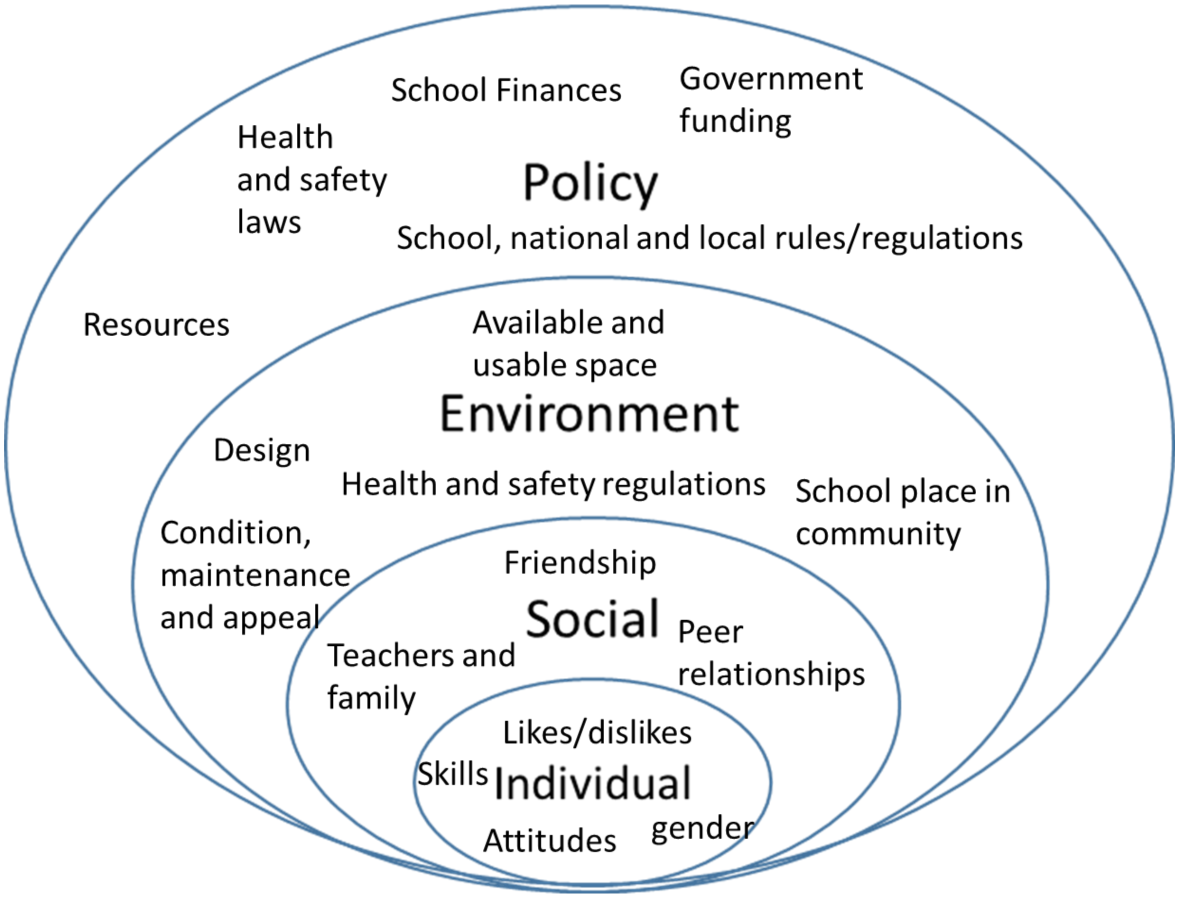


Figure 2.4 Socio-ecological model of physical activity and health (adapted from Davison and Birch 2001) for individual behaviour change in a school setting

Cohen et al. (2015) used a SEM framework when designing the components of a multi-component physical activity and FMS intervention. The intervention consisted of components aimed to motivate and encourage physical activity at an individual and social level with rewards given to individuals who achieved certain tasks (phase 1). Furthermore, the research team supported the implementation of physical activity policies within the intervention schools, using a range of strategies to engage local sports clubs and community links to help support this element (phase 2).

Cohen et al. (2015) intervention, named ‘SCORES’ for Supporting Children’s Outcomes using Rewards, Exercise and Skills, assessed outcomes at midpoint (six months) and post intervention (twelve months). The authors noted that despite a slight increase in the intervention group MVPA there were no notable between group differences at the mid-point of the intervention but significant between group differences for FMS and MVPA at the twelve month period, in favour of the intervention group. One of the tenets of the SEM is that significant and sustainable changes will not be observed without adequate recognition and application of components at each level of the SEM. This is likely the cause of the delay in outcome effects observed in the SCORES intervention, due to the policy changes not implemented until phase 2 (six months), at which point differences between control and intervention groups began to appear.

Alternatively, the delayed intervention effect might be due to contributions from the inclusion of FMS in the activity sessions. Movement skill acquisition is a developmental process (Cohen et al. 2015) and the longer term improvements in MVPA might have been a result of the time needed to practice and master certain FMS necessary to move on to more complex and dynamic movement skills. In addition to accelerometer compliance in this study, the lack of a follow up limits the usefulness of this study findings longer term. It is likely, as mentioned earlier in this chapter that the positive outcomes observed will follow similar trajectories to the control group once the intervention and support of the research staff are removed and the implemented policies slowly filter out replaced by policies that match the schools current agenda.

One way to overcome this phenomenon is to consider the child as an active part in the research development process and not simply as a participant in a research study (Kellett 2005). It is normal procedure for adult researchers and school staff to design intervention activities that they (the adult) perceive as likely to have the desired effect whilst attempting to create play spaces that children will enjoy and engage with (Tremblay, Gray, Babcock et al. 2015). Furthermore, whilst interventions underpinned by each of the SEM components are effective during the intervention period (Cohen et al. 2015), engaging with key stakeholders, namely the school staff and children is likely to elicit long term sustainable outcomes (i.e., lifestyle behaviour change) (Lander, Salmon, Morgan et al. 2020). Likewise, including the children's perspectives during the development phase of environmental interventions might help identify current barriers and facilitators at the various levels of the SEM, serving two main purposes. Firstly, it can act to reduce the overpowering adult agenda (Jones 2008). Secondly, including the child in appropriate planning activities will contribute to a reversal of the adult-child power divide (Jones 2008) putting children in a more influential, driving role in the design and implementation of individual, social, environmental and policy changes that will work for them and for the school.

Sallis, Bauman and Pratt (1998) discussed the advantages of adopting an environmental approach to physical activity promotion. The authors of this study reviewed seven previous evaluations of environmental and policy interventions and proposed a model for designing and developing future interventions. In addition, they identified a number of key agencies and coalitions (for example, education, sport and fitness industry) for driving the environmental and policy changes.

There are a number of environmental settings in which children have an opportunity to be physically active, such as; active commuting, curricular PE, community and sports clubs, after school clubs and the home (Sallis et al. 1998; Loprinzi, Cardinal, Loprinzi and Lee 2012). However, as mentioned previously, the number of settings considered as a safe opportunity for physical activity are declining (Hofferth and Sandberg 2001; Carver et al. 2008; Carver et al. 2017). Nevertheless, the environment can play a key role in determining the physical activity behaviours of children (Biddle et al. 2009; Loprinzi et al. 2012; Sterdt et al. 2014) if adequate consideration is given to ensuring that the environment is conducive to physical activity behaviours (Sallis et al. 1998). There is a growing body of evidence to suggest that school based strategies are more effective than home/family settings for implementing physical activity interventions (Salmon, Booth, Phongsavan et al. 2007; van Sluijs et al. 2007).

It could be expected that by manipulating some of the individual environmental factors within schools there would be a significant effect on the health behaviours of children (Wechsler, Devereaux, Davis and Collins 2000).

2.4.2 School based physical activity and health promotion

School environments and policies can act to either promote or prohibit particular behaviours throughout the school day. Following on from the 2012 Olympic Games, the UK Department for Education (DfE 2013) developed the primary school physical education and sport premium (PPESP) which releases funding each year to eligible primary schools to be used to facilitate any changes deemed necessary (school environment and policies) to promote a higher level of physical activity. The PPESP is released annually and for the academic year 2019 to 2020 the UK government released £320 million of government funding, with eligible schools receiving £16,000 plus an additional £10 per pupil. The money is provided so schools can develop their PE, improve physical activity levels and create a sport strategy to ensure that all pupils have the opportunity to live healthy and active lives (DfE 2014/2019). Not only can this be considered an acknowledgement of some the concerns surrounding primary school PE (Griggs 2010) but also that the responsibility for physical activity and health promotion goes beyond PE lesson time.

The PPESP requires that schools publish details on how they have spent their funding whilst the office for standards in education (OFSTED) assess and report on the effectiveness of its use. Following its inception, there has been a number of issues raised concerning the utilisation, sustainability and measurement of the PPESP impact (Griggs 2016; Griggs 2018). For example, the money can be used to develop PE through development opportunities for current staff or employment of permanent PE staff. However, it should not be used to outsource PE to external coaches/groups. Furthermore, as many years pass between OFSTED visits, the infrequent nature of this assessment strategy is unlikely to encourage effective spending (Lawless, Borlase-Bune and Fleet 2019) with many primary schools continuing to spend their funds on simply outsourcing their PE and sports provision (Griggs 2018) emphasising the lack of knowledge and value placed on PE and physical activity promotion at primary level education (Lawless et al. 2019).

There is an inconsistency in the way primary schools spend their PPESP and this makes it difficult for an accurate evaluation of the effects of the funding on health and physical activity promotion within schools (Griggs 2016). However, there has been a continued effort from researchers exploring the effects of school based physical activity interventions on children's physical activity levels and health and well-being (Van Sluijs et al. 2007).

Schools are encouraged to promote physical activity for all (DfE 2019) as during the school day each child, irrespective of social and cultural demographics should have access to the same health opportunities. Furthermore, the school environment is believed to be an ideal setting to promote a higher level of engagement in MVPA due to the existing PE frameworks that exist within schools and the large amount of time children spend in the school environment on a daily basis (Gråstén et al. 2017). By utilising the school environment, physical activity interventionists have the potential of reaching larger numbers of children than would be possible in other settings (home and community) and without stigmatization or discrimination (Kriemler, et al. 2011).

2.4.3 Physical Education

Salmon et al. (2007) found that interventions delivered in the school setting that included some focus on PE, that involved activity breaks, or that made simple environmental changes in the setting were the most effective among primary school children. However, the sustainability of such interventions is rarely reported (Salmon et al. 2007). Nonetheless, interventions focussing on increasing the amount and quality of PE have displayed promising results on physical activity during the school day (Sallis, McKenzie, Alcaraz et al. 1997) and are likely to be sustainable due to subtle changes in the existing curriculum structure (Salmon et al. 2007). Sallis et al. (1997) explored the difference between a specialist led (trained PE teachers) PE curriculum, a trained classroom teacher led curriculum (classroom teacher with some PE training by research group) and a ‘usual curriculum’ (control group) on children’s MVPA levels during class time and out of school. The authors reported that children in the specialist led group participated in twice as much MVPA during class time compared with controls. Furthermore, both intervention groups increased the contribution PE had to children’s weekly MVPA (teacher led = 32 minutes MVPA per week; specialist led = 40 minutes MVPA per week) in comparison to the control group (18 minutes MVPA per week). Although these findings suggest investment in teacher training for PE is likely to increase the quantity of MVPA children take part in during lesson time, the amount of PE provided per week was less than 80 minutes for all groups.

Despite the contribution PE has on children’s physical activity levels during school (Loprinzi et al. 2012) there is little evidence to suggest it contributes to the recommended daily amount of MVPA (Sallis et al. 1997; van Beurden, Barnett, Zask et al. 2003; Fairclough and Stratton 2005; Wood and Hall 2015). The most recent UK Active Lives CYP survey (Sport England 2019) found that 60% of children do not achieve the minimum recommendation of 30 minutes of MVPA during the school day, and that this number has remained unchanged from the previous year’s report. Furthermore, there is a considerable variation in activity levels during PE due to the content specific nature and pedagogical factors (lesson objectives, teaching styles etc.) (Fairclough and Stratton 2005). PE remains, however, a crucial part of a child’s day as it provides children with an opportunity to learn the skills needed and develop the confidence to be active in other periods of the day (Stodden et al. 2008) and for lifelong physical activity participation (Sallis et al. 1997; Kirk 2005). Furthermore, PE provides at least a moderate amount of MVPA for the least active children (Fairclough and Stratton 2005), who may struggle to find opportunities to be active once the school day is over.

Despite the importance of PE for developing FMS competence and contributing to children’s physical activity participation (Fairclough and Stratton 2005), opportunities to engage in quality PE at primary school are limited (Griggs 2010) with no statutory guidance on the amount of the curriculum timetable primary schools should dedicate to PE. Furthermore, though the national curriculum for PE in the UK sets out that PE is compulsory, and provides brief guidance on what should be delivered, it is simply a guide, with no reliable regulation or monitoring of the resources and money spent on delivery. The UK spending budget announced in March 2020 stated that £29 million per year will be allocated by the year 2023/24 to support high quality PE teacher training and help schools make the best use of their sport facilities (HM Treasury 2020). It is unclear whether this funding will be provided in addition to the PPESP or in place of it. Until the PPESP for 2021 (and beyond) is reviewed in July 2020 the future of primary school PE and the in school MVPA levels are likely to remain unchanged.

2.4.4 Break-time and the primary school playground

In addition to PE, school break-times offer a period of time, occurring daily, that offers a variety of opportunities for children to be physically active. The variety of strategies and the less structured environment on the primary school playground during break-times is more suitable for the intermittent physical activity patterns of children (Loprinzi et al. 2012; Escalante et al. 2014). Escalante et al. (2014), observed a large percentage of children in some form of physical activity leading to suggestions that the primary school playground is an ideal setting for children to be active.

However, a study by Wood and Hall (2015) assessed PE and break-time physical activity levels to determine which is more effective at promoting physical activity in primary school children. The authors concluded that PE lesson physical activity levels were largely influenced by the lesson content with team games resulting in the highest amount of physical activity recorded. Furthermore, break-time physical activity was found to be lower than that of PE lessons (Wood and Hall 2015). Although this study was small cross sectional comparison of one schools PE and break-times, the findings lead one to infer that implementing physical activity interventions during school break-times could contribute to an increase in children’s MVPA levels.

In contrast, authors of a cross sectional study published patterns of physical activity in children (11.8 years old) and identified that there are three distinct peaks in activity throughout a child's day, occurring on the morning commute to school, during lunch time and the period immediately after school (Riddoch, Mattocks, Deere et al. 2007). This suggests that the lunch break-time is already one of the more active periods in the school day and therefore it may be more appropriate to target a period of the day when children are less active. However, the same study also highlighted that children achieved a median number of 20 (interquartile range: 13 to 31) minutes of MVPA across the whole day suggesting that regardless of more or less active periods in the day, the amount of sustained MVPA is insufficient. Moreover, the study participants were 11.8 years of age, suggesting data was collected either in the final months of primary school or early in their first year of secondary school. Therefore, in either instance the environment represented by this data is not one that the children will be familiar with due in part to changes in routine and increased curricular pressures (i.e., SAT's exams and adjusting to secondary school). Furthermore, the authors identified that total physical activity and MVPA participation was seasonally affected but did not elude to any changes in the daily physical activity patterns throughout the seasons. It would be important to understand whether the peaks in activity occur at the same times of day and if the peaks flatten out during winter months.

Wiersma, Lu, Hartman and Corpeleijn (2019) conducted a similar cross-sectional analysis of accelerometry data from 958 young children (mean ± SD; 5.7 ± 0.8 years) and highlighted that MVPA levels increased throughout the day, peaking in the segment immediately after school (3 to 6pm) with 9.3% of the whole day (7am to 9pm) spent in MVPA. The difference between the daily patterns presented in these two studies could be due to differences in accelerometer type, epoch duration and MVPA cut-points used.

For example, Riddoch et al. (2007) collected uniaxial accelerometry data (Actigraph MT1), using a one minute epoch and cut point for MVPA defined as above 3600cpm; whilst Wiersma et al. (2019) used a tri-axial accelerometer, a 15 second epoch and a MVPA cut point of ≥

3908 cpm. The use of a longer epoch, and a single axis accelerometer in the study by Riddoch et al. (2007) may have underestimated the amount of higher intensity physical activity in other periods of the day (e.g., PE), when the activity children performed was more sporadic and in short bouts (Bailey, Olsen, Pepper et al. 1995). Furthermore, the wear location of the accelerometer (hip worn) in both studies may have missed any contribution from the more discrete upper body movements performed (Duncan et al. 2019). Finally, as children age, their lifestyle behaviours, likes and dislikes and social position change, which is likely to affect the physical activity behaviours and patterns of physical activity throughout the day.

Despite contrasts between the aforementioned studies, the total amount of MVPA reported in Ruddoch et al. (2007), Wiersma et al. (2019) and in the CYP active lives survey (Sport England 2019) suggest that a large proportion of primary school children are failing to achieve adequate levels of MVPA both inside and outside of school.

Short-to-medium term (six weeks to six months) playground interventions have been found to increase physical activity levels of children during school break-times (Escalante et al. 2014) using playground markings (Stratton 2000; Stratton and Leonard 2002; Stratton and Mullan 2005), the provision of games equipment (Verstraete, Cardon, De Clercq et al. 2006) and portable equipment (Parrish, Okely, Batterham et al. 2016). Escalante et al. (2014) systematic review explored the effect of a variety of playground interventions (eight studies) including playground markings, games equipment, physical structures and combinations of these methods. The authors concluded that playground interventions focussing on one of the aforementioned methods were not effective in increasing physical activity levels of pre-school (under 5 years old) or primary school children (5 to 11 year olds) and that a combination of playground markings plus physical structures increased physical activity levels in primary school children in the short to medium term. However, there has been limited research exploring longer term effects of playground interventions on physical activity levels of primary school children.

One study, by Ridgers et al. (2010) established that during the period between six months and twelve months of a playground intervention (combined playground markings and physical structures) the physical activity levels (total and MVPA) of the children in the intervention school (8 to 11 years old) declined, suggesting additional approaches; such as supervisor training, equipment refresh and repainted markings may be needed at regular points throughout the school year to maintain the increase in physical activity levels observed at six months. Furthermore, there is currently a need for further studies to explore the effect of playground and indeed school based interventions in general on contributing to the recommended daily levels of MVPA (Van Sluijs et al. 2007; Escalante et al. 2014) and FMS development.

There are a number of benefits to children's well-being beyond an increase in physical activity levels that increasing the use of the primary school playground can have. The important role of play and active play have been identified earlier in this thesis (e.g., cognitive, physical, social, environmental). However, the importance of outdoor play is underpinned by many of the philosophical perspectives of Friedrich Froebel (circa 1885), such as importance of children's self-directed activity and play, respecting children independent decision, and the centrality of nature (Smedley and Hoskins 2020). The link to the outdoors and nature is a key part to Froebel's ideas, developing a fundamental relationship with nature and the environment is critical in understanding the unity and interconnection of all things (Smedley and Hoskins 2020). Cullen (1993) found that the length of time children spent outdoors led to an increase in the creativity of children's play in early years children (5 years old). Part of the appeal of outdoor play to children is the perception of independent play, without the need for adult assistance. Although free play, outdoors may be insufficient to achieve physical objectives (e.g., achieving physical activity guidelines) (Cullen 1993), the identification and exploration of 'risk' and 'challenge' help children explore their limits of their ability (Tovey 2017), and with effective monitoring and facilitation, there could be a more effective use of outdoor play spaces (Cullen 1993).

However, a decrease in outdoor play opportunities due to increased urbanisation with poor provision of play facilities (Sleap and Warburton 1996; Carver et al. 2008) and increases in parental anxieties about safe outdoor play (Valentine and McKendrick 1997) has led to a decrease in time children spend outdoors, unsupervised (Hofferth and Sandberg 2001). Although Froebel's development of *'kindergarten'* (translation: children's garden) was from a pedagogical perspective (Smedley and Hoskins 2020), the use of educational settings, such as primary schools, provide a safe setting to promote the use of outdoor space. The DfE (2014) recognised the importance of outdoor space for both pedagogical purposes and physical development, and produced *'area guidelines for mainstream schools'* which set out internal and external (outdoor) guidelines for school sites accommodating children from 3 to 18 years of age. The document includes recommendations for various categories of external space, such as; hard outdoor PE, soft outdoor PE, hard informal and social, soft informal and social, and habitat. The 'habitat' spaces include a range of outdoor classroom spaces, with many schools introducing 'waldkindergarten' or forest schools, which align with Froebel's philosophy of nature as central to unifying all aspects of children's development (social, emotional, physical).

However, many inner city, urban schools are unable to provide this valuable experience due to environmental constraints, and although once a frequent part of the childhood curricula, outdoor play experiences are steadily declining (Wellhousen 2002). The main opportunities for children to be outdoors during the school day occur during break and lunch-time periods. However, due to the increased perception of break-times as a relatively unimportant period in the day (Baines and Blatchford 2019a), in addition to an increase in curricular related pressure (e.g., Ofsted inspection) (Erwin et al. 2014) break-times and therefore the opportunity for outdoor play is decreasing in volume and duration (Baines and Blatchford 2019b).

To be able to reverse this underutilisation of schools outdoor spaces, it is important to identify current child and adult perceptions on the current use of primary school playgrounds and identify current socio-ecological barriers to a more effective use of the space. These outcomes can be used to inform and educate stakeholders (head teachers, teacher, policy makers, local government, and ministers for education) on a more effective use of playground space.

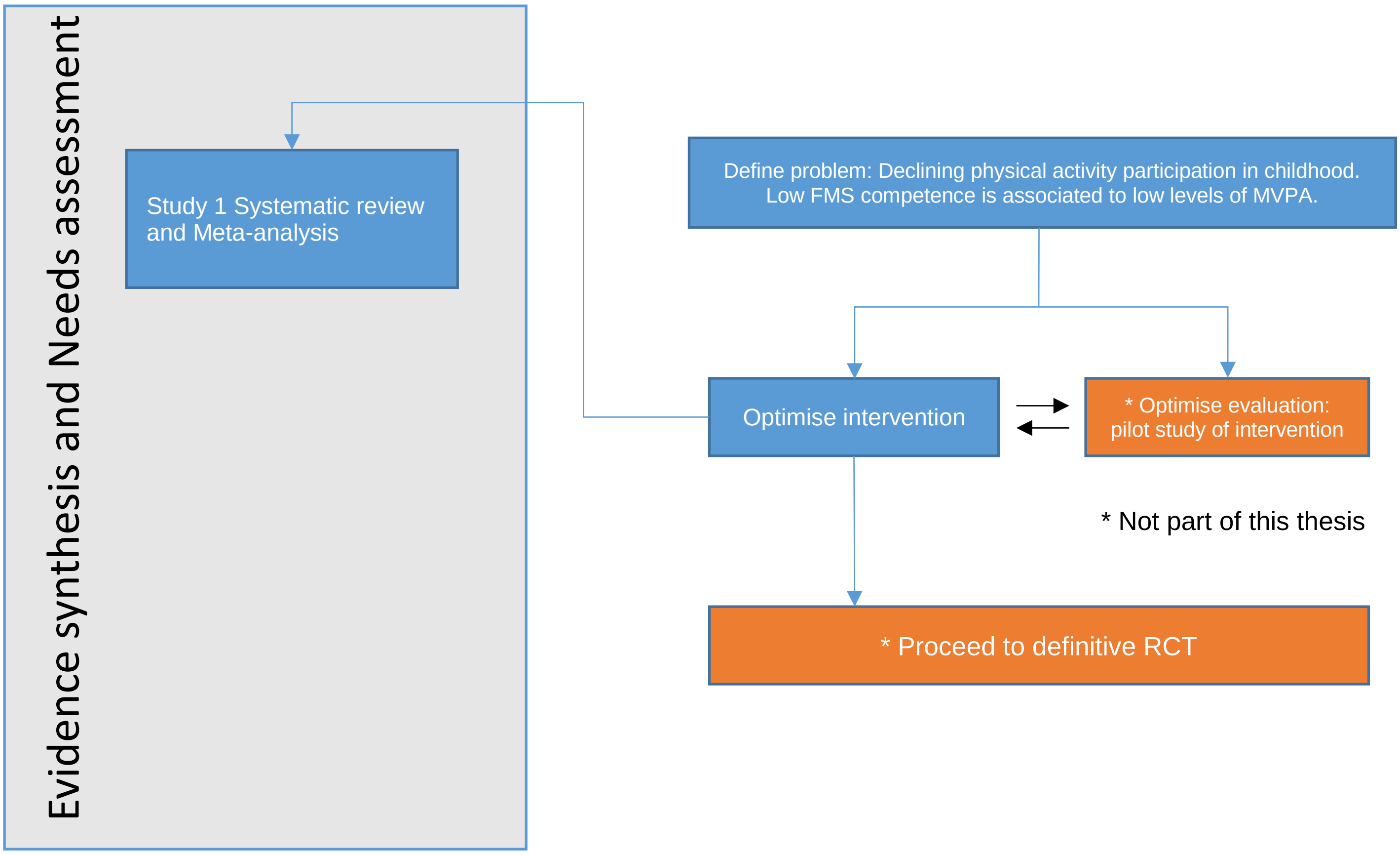
2.5 Summary of the literature

Physical activity throughout childhood is important for a number of physical, psychological and social factors. There is sufficient evidence to suggest a strong association between FMS and physical activity in childhood. However, there is a lack of consistency in the effects of FMS interventions on physical activity levels of primary school children. These results are likely due to the way in which the research conceptualise and measure FMS. However, the variety in intervention characteristics and the lack of detail in the reporting of intervention components makes it hard to identify the important aspects of effective FMS interventions.

The primary school playground offers a unique and versatile environment that could be utilised to encourage the development of a comprehensive array of FMS, contributing to increases in school day and whole day MVPA. In addition, there is sufficient evidence to suggest that utilising a socio-ecological approach during the design and implementation of primary school physical activity interventions leads to greater improvements in children's physical activity levels. However, FMS interventions using this approach, focussing predominantly on the primary school playground are lacking.

Future studies should consider the use of the primary school playground as an environment that would encourage children to develop the FMS taught in other periods of the school day (e.g., PE) by utilising the outdoor spaces available in line with a 'Froebelian' perspective. Furthermore, it can be hypothesised that by utilising a socio-ecological approach that acknowledges the relationship between the multiple factors within the primary school setting (individual, social, environmental and policy); and by acknowledging the valuable contributions key stakeholders (e.g., school staff) and children could make in the design and development of an intervention, that more sustainable, long term improvements in MVPA can be expected.

CHAPTER 3: THE EFFECT OF FMS INTERVENTIONS ON MODERATE TO VIGOROUS PHYSICAL ACTIVITY IN PRIMARY SCHOOL CHILDREN: A SYSTEMATIC REVIEW AND META-ANALYSIS



Chapter aim: The primary aim of this chapter is to evaluate the effectiveness of FMS interventions on improving daily levels of MVPA.

Study design: Systematic review and random effects meta-analysis of randomised and non-randomised controlled trials

Key points: Despite a substantial range in intervention effects (-16 to 18 minutes of MVPA), physical activity interventions including FMS activities have a pooled intervention effect of 4.3 minutes (95%CI: -0.03 to 8.8) of MVPA per day compared to controls. This is greater than the defined minimal clinically important difference (MCID) of 3.6 minutes of MVPA. Studies that attempted to conceptualise and define FMS by combining at least one of Logan et al. (2018) operational definition conceptualising criteria and using a measure of FMS had a positive effect on daily MVPA (12.8 min/day; 95%CI: 6.51 to 19.1; F=9.3, df=3, dfErr=10, p=0.003) compared to studies that did not meet the established criteria. Finally, meta-regression for the three levels of Logan's criteria showed a linear increase in MVPA with studies using all three criteria experiencing the largest additive effect (15.7min/day: 95%CI: 8.9 to 22.6; F=11.2, df=3, dfErr=10, p=0.0016).

3.1 Introduction

Higher physical activity levels are associated with physiological, psychological and psychosocial health among children (Strong et al. 2005; Jago et al. 2017). However, many children and adolescents do not meet MVPA recommendations (HSE 2008; Griffiths et al. 2013). Furthermore, the volume of physical activity (total and MVPA) begins to decline by the age of 7 years (Kwon et al. 2015; Jago et al. 2017; Farooq et al. 2018) or in some cases earlier (Reilly 2016).

An important contributor to the amount of physical activity children take part in is fundamental movement skill (FMS) competence. FMS consist of three main constructs; locomotor (run, hop, jump, slide, gallop, leap); object control (strike, dribble, kick, throw, underarm roll, catch); and balance/stability skills (non-locomotor skills such as body rolling, bending and twisting) (Gallahue et al. 2012). Stodden et al. (2008) suggested that physical activity and FMS have a reciprocal relationship during the early years of childhood, whereby a higher level of physical activity engagement drives FMS development. Development of FMS during early childhood is thought to be critical to physical activity participation throughout primary school years (Hardy, King, Farrell et al. 2010). Early development of FMS forms a skill base that acts as a foundation to master the more complex physical activities needed throughout the life course (Clark and Metcalfe 2002; Lloyd and Oliver 2012; Barnett et al. 2016a; Logan et al. 2018). Furthermore, a higher level of movement competence attenuates the decline in physical activity throughout childhood (Lopes et al. 2012) and is important for physical development and physical activity across the lifespan (Stodden et al. 2008).

Despite the growing popularity to include FMS in childhood physical activity interventions (Van Capelle et al. 2017), the FMS components of the interventions are not always clear. The duration of the intervention and the frequency and intensity of the individual sessions can impact the effectiveness of the intervention (Hoffmann et al. 2014). Likewise, there are additional factors which could affect the magnitude of the effectiveness of FMS interventions

(Morgan et al. 2013; Hoffman et al. 2014; Wiltshire, Lee and Williams 2017), which until now have not been fully addressed. For example, it is widely accepted that FMS do not occur naturally over time and require teaching, training, practice and modelling, which are all important to the development of FMS due to their ontogenetic characteristics (McKenzie et al. 1998; Stodden et al. 2008; Barnett et al. 2016a; Barnett et al. 2016b). This latter statement would suggest that interventions which include FMS with an expectation that physical activity will naturally increase as a consequence ignores the complex nature of movement skill development; described as a continuous change in movement behaviour throughout the life cycle through the interactions of tasks, individual biology and environmental conditions (Gallahue et al. 2012).

Previous reviews have highlighted positive associations between FMS composite score (combined object control and locomotor constructs), physical activity (Barnett et al. 2016b), and health related physical fitness (Cattuzzo et al. 2016). Lubans et al. (2010) conducted a systematic review including 19 studies (15 cross sectional, 2 longitudinal, 2 experimental) exploring the association between FMS and physical activity across childhood. From the 15 cross-sectional studies included, Lubans et al. (2010) identified positive associations between FMS competency and physical activity and cardiorespiratory fitness in children and adolescents. However, data extracted from the two longitudinal studies provided less conclusive evidence for a FMS and physical activity relationship. A meta-analysis was not possible due to an inadequate number of longitudinal and experimental studies reporting these variables.

Much of the recent research highlights the positive associations between FMS and physical activity in early year’s (Barnett et al. 2016b; Cattuzzo et al. 2016; Van Capelle et al. 2017; Engel et al. 2018; Jones et al. 2020). Others combined data for early year’s children, primary school children and adolescents (Lubans et al. 2010; Engel et al. 2018). However, the effectiveness and determinants of FMS interventions in 5 to 11 year old (primary school) children are less understood. Nonetheless, there is an expectation that FMS interventions will increase physical activity in children and that these two outcome go hand-in-hand.[1] See footnote However, Dudley et al. (2011) identified that the interventions that had a direct instruction of activities from teachers who had previous and ongoing training were the most effective at improving children's movement proficiency and physical activity levels. Although this reinforces the importance of the pedagogical methods of delivery for intervention effectiveness, Dudley et al. (2011) did not state whether all of their studies included a FMS intervention, and only that it was measured as an outcome. Tompsett et al. (2017) highlighted that despite 93% of studies included in their systematic review on the most effective characteristics of an FMS intervention, there was a vast array of FMS definitions and measurement tools used. Without a clear definition of what constitutes an FMS intervention during the selection of studies for a systematic review, there is a risk that a number of key studies may have been missed during searches or incorrectly excluded/included during selection.

Furthermore, similar to previous reviews (Lubans et al. 2010; Engel et al. 2018) Tompsett et al. (2017) and Dudley et al. (2011) were inclusive of children from 5 to 18 years of age without any subgroup analysis or discussion on the variety of outcomes by age, and lacked a quantitative analysis of outcomes (i.e., a meta-analysis). Therefore, a recommendation for a qualitative synthesis and meta-analysis of studies which have explored the effectiveness of FMS interventions on FMS and physical activity outcomes in primary school age children is needed.

There has been a rise in the development of interventions utilising FMS with the primary aim of increasing physical activity levels of children (Corder, Brown, Schiff et al. 2016; McKenzie et al. 1997; Eather, Morgan, Lubans 2013; Barnes et al. 2015; Morgan et al. 2018). However, to our knowledge a thorough synthesis of the findings on the effect of FMS interventions on

[1] Reviewer comment from rejected publication attempt*: "FMS interventions are expected to improve physical activity (those two go hand-by-hand); this is not surprising*". Hence the inclusion of this statement here in the introduction. However, I believe this belief holds some of the responsibility for the range in intervention effects presented later in this chapter.

daily levels of MVPA in primary school aged children is lacking. The aim of this review is to synthesise and meta-analyse the effectiveness of FMS interventions at improving daily levels of MVPA in 5 to 11 year olds. The secondary aim is to explore the difference between studies that "expect" positive outcomes from the FMS activities versus those that fully embody the concept of FMS. Although it is acknowledged that there are many interpretations of FMS and that often journal word counts restrict the inclusion of a comprehensive definition we decided to use Logan et al. (2018) operational definition to be able to perform a linear meta-regression. The criteria used were; 1) inclusion of a statement that suggests FMS are the "building blocks" (or similar terminology) of more advanced, complex movements required to participate in games, sports or other context specific physical activity; 2) inclusion of a statement that provides specific categories of skills that compose FMS such as object control, locomotor, or stability skills; and 3) provide at least one specific example of FMS (i.e. running, jumping, throwing etc.) and a measure of FMS.

3.2 Methods

This systematic review and meta-analysis was registered with Prospero in May 2017 (CRD42017058718: Appendix A) and follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Liberati, Altman, Tetzlaff et al. 2009).

3.2.1 Search strategy

Eight electronic databases (MEDLINE, CINAHL, PubMed, Web of Science, SportDiscus, EMBASE, ERIC, and Scopus) were systematically searched. Reference lists of included articles were additionally screened for any relevant articles.

Searches were conducted from inception up to September 2019. The search strategy was built to include all search terms/keywords using the PICO (Population, Intervention, Control, Outcomes) approach for systematic reviews. A pilot search (of titles/abstracts/keywords/full texts) of previously known articles identified keywords used in the search strategy. Keywords/terms associated with "children" (population), "fundamental movement skills" (intervention), "controlled" (Comparator/design) and "physical activity" (outcome) were used to create a Boolean search phrase using the operators 'OR' and 'AND' (e.g. "Child*" OR "Primary School"… AND "Fundamental movement skills" OR "Motor skills"…AND "randomi?ed control* trial"…AND "physical* active*"…). A full search strategy can be seen in Table 3.1.

Table 3.1 Search phrase used in systematic search

Search term	Keywords
1. Population	Child*" OR "children" OR "childhood" OR "primary school" OR "school" OR "elementary school" OR "1st grade" OR "2nd grade" OR "3rd grade" OR "4th grade" OR "5th grade" OR "kindergarten" OR "intermediate school" OR "first school" OR "middle school" OR "school age*" OR "5 11 year old" OR "young people" OR "infant"
2. Intervention	"fundamental movement skills" OR "fundamental motor skills" OR "FMS" OR "movement skill" OR "playground activity" OR "physical activity" OR "exercise" OR "motor coordination" OR "movement ability" OR "motor competence" OR "motor skill competence" OR "motor ability" OR "motor development" OR "motor skill development" OR "skill proficiency" OR "motor function" OR "gross motor" OR "physical literacy" OR "physical competency" OR "stability" OR "balance" OR "physical capability" OR "locomotor" OR "object manipulation" OR "object control" OR "PE" OR "Physical education"
3. Control	"Nonrandomi?ed control* trial" OR "randomi?ed control* trial" OR "RCT"
4. Outcome	physical activity" OR "PA" OR "MVPA" OR "moderate to vigorous physical activity" OR "fitness" OR "physical capacity" OR "exercise capacity" OR "aerobic capacity" OR "aerobic exercise" OR "aerobic fitness" OR "energy expenditure" OR "metabolic equivalent" OR "accelerometer" OR "pedometer" OR "observation" OR "heart rate" OR "physical fitness" OR "physical exertion" OR "physical endurance" OR "exercise" OR "exercise movement techniques" OR "accelerometry"
Search Phrase	1 AND 2 AND 3 AND 4

3.2.2 Study selection and screening strategy

Returned articles from database searches were independently exported into a Microsoft Excel worksheet which identified duplicate articles across databases. Once duplicates were removed, three independent reviewers (myself and two supervisors; AI, LA) screened titles and abstracts from the remaining articles and articles from additional sources, against previously agreed eligibility criteria (Appendix B).

Articles were eligible if they were a randomised or non-randomised controlled trial that implemented a physical activity intervention in typically developing 5 to 11 year old children, with a focus on FMS (identified by use of FMS terminology or by explicit FMS activities in the methods sections of reviewed studies). Furthermore studies needed to have included an objective, validated and quantitative measure of MVPA levels.

Studies were excluded if they focussed on one specific population or condition (e.g., overweight/obese, developmental coordination disorder, Down syndrome, other neurological/movement disorders) due to the negative associations with FMS competence and physical activity levels (Lopes et al. 2012; Tsai, Wang, Tseng 2012; Gentier et al. 2013; Schott, Holfelder and Mousouli 2014; Barnett et al. 2016b). Furthermore, studies were excluded if they had a cross-sectional or longitudinal methodology, and if the articles were not original research (i.e., reviews, surveys, opinion pieces, book chapter). Interventions which were conducted solely at home or in a lab setting were also excluded as this would not accurately represent the environments important to this study.

Finally, texts that were not available in English language were excluded. A full description of inclusion and exclusion criteria are presented in Appendix B.

MG screened all titles and abstracts, whilst AI and LA screened half each. Any disagreements and uncertainty in eligibility were discussed and agreed with a third reviewer (AI or LA) until a consensus was reached. Eligible studies selected from the first screening were retrieved and read in full by three reviewers (MG, AI and LA). Any disagreements during this process were discussed and agreed before continuing. In cases where agreements were not possible because of lack of information authors were contacted for clarification.

3.2.3 Data extraction

Once articles were established as meeting the eligibility criteria, three researchers (MG, AI, LA) independently gathered all relevant data using a standard data extraction form (Microsoft Excel, Microsoft, Redmond, USA). Articles that duplicated data from multiple reports were reviewed again by two researchers (MG and AI) and all available data collated to ensure we had the most complete data set (Al-Khudairy, Loveman, Colquitt et al. 2017). Any discrepancies at this stage were discussed and agreed by a third reviewer (LA). Authors were contacted in cases where data were presented as median and ranges (in place of mean and SD) and where data were unclear or missing (Salmon et al. 2008; Fairclough, McGrane, Sanders et al. 2016; Johnstone, Hughes, Janssen, Reilly 2017; Adab et al. 2018; Taylor, Noonan, Knowles et al. 2018; Johnstone, Hughes, Bonnar et al. 2019). In cases when the authors did not respond or were unable to locate the relevant data, the articles were subsequently excluded from the meta-analysis (Caballero, Clay, Davis et al. 2003). Graph digitizer software (DigitizeIt, Brainschweig, Germany) was used to obtain data from studies where data were only available in figures (Fairclough et al. 2016). Rakap, Rakap, Evran and Cig (2016) recently demonstrated a high degree of reliability and validity in the use of the 'DigitizeIt' software and concluded that data extracted using this method can be used in meta-analysis with a high level of confidence.

Higgins and Green (2011) equations were used to convert data to the desired format (e.g., SE to SD), for combining groups (e.g., male and female; MPA and VPA) and for calculating the effective sample sizes for any clustering effect in cluster trials. Extracted data included participant characteristics (height, weight, % male/female, BMI, % overweight/obese, SES, ethnicity), whether an operational definition of FMS was included in the article (Logan et al. 2018); age group, sample size, number of schools and classes used in control and intervention groups; intervention and control group characteristics; study details (design, setting, unit of randomisation, frequency and duration of sessions, intervention duration, time to follow up); FMS measurement tool used and domains measured; physical activity measurement method, monitor type (accelerometer, pedometer), monitor details (type, classification of wear time and non-wear time, cut-points used, epoch) and analysis methods. Baseline and outcome data extracted included baseline, post and follow up MVPA in minutes per day (accelerometry), step count (pedometers), and FMS competence.

3.2.4 Quality assessment

The Cochrane risk of bias 2.0 (RoB2.0) (Higgins, Sterne, Savović et al. 2016) and the risk of bias in non-randomised studies of interventions (ROBINS-I) (Sterne, Hernán, Reeves et al. 2016) were used by three independent reviewers (MG, AI, LA) to evaluate quality of eligible studies. Studies assessed using the RoB2.0 were scored as either 'low risk', 'some concerns' or 'high risk' for each domain; (1) bias arising from the randomization process; (2) bias due to deviations from intended interventions; (3) bias due to missing outcome data; (4) bias in measurement of the outcome; (5) bias in selection of the reported result. Overall study bias was scored using the algorithms provided in the RoB2.0 guidance documents. In brief, a study was judged as 'low risk' if the study scored low in all domains, 'some concerns' if the study was judged to raise some concerns in at least one domain but no high risk judgements, and 'high risk' if the study was judged to be either high in at least one domain or to have some concerns in multiple domains (Higgins et al. 2016).

The studies assessed using the ROBINS-I tool, involved identifying preliminary confounders and assessing as either 'low risk', 'moderate risk', 'serious risk', or 'critical risk' for (1) bias due to confounding; (2) bias in selection of participants into the study; (3) bias in classification of interventions; (4) bias due to deviations from intended interventions; (5) bias due to missing data; (6) bias in measurement of outcomes; (7) bias in selection of the reported result (Higgins et al. 2016). Overall study bias was judged 'low risk' if the study was judged as low for all domains, 'moderate risk' if judged to be low or moderate across the domains, 'serious risk' if judged serious in at least one domain and 'critical risk' if judged to be critical in at least one domain (Sterne, Higgins, Elbers et al. 2016).

3.2.5 Data analysis

Comprehensive meta-analysis (CMA) software (Version 3; Biostat, Inc. Englewood, NJ07631, USA) was used to perform a random effects meta-analysis to determine the pooled intervention effect (mean difference) on minutes spent in MVPA. Uncertainty in the pooled effect was expressed as 95% confidence intervals (CI) with between study heterogeneity (Tau *T*) quantified using DerSimonian and Laird (1986) (methods of moments) estimator with Hartung-Knapp t-distribution. DerSimonian and Laird estimator accounts for the greater heterogeneity from the inclusion of studies with greater treatment effects (generally studies with greater potential for bias) in the analysis by assigning a greater variability to the estimate of overall treatment effect (DerSimonian and Laird 1986). The inclusion of the Hartung-Knapp t-distribution results in more adequate error rates especially when the number of included trials are between two and twenty (IntHout, Ioannidis and Borm 2014) and where the individual trial sample sizes and standard errors vary (IntHout et al. 2014; Röver, Knapp, Friede et al. 2015). Compared with traditional methods (z-distribution), Hartung-Knapp t-distribution is more accurate in this scenario as it doesn't rely on the use of 1.96 to calculate the 95% CI and instead uses a more appropriate t-value for the degrees of freedom, therefore producing a wider, and more representative CI for the smaller number of studies.

Eggers regression coefficient and 95% CI were used to explore potential small study effects. Egger, Davey Smith, Schneider and Minder (1997) regression model tests for linear associations between the individual intervention effects and their standard errors, where smaller studies with larger effects are likely to have large variation in their estimates (standard error).

In the case of substantial between study heterogeneity, categorical meta-regression was completed to explored using the following variables as moderators: 1*) 'If a measure of FMS used with at least one of Logan et al. (2018) criteria'* (two levels: Yes/No) 2) *'multicomponent vs single intervention'* (two levels); 3) *'instructor type'* (two levels: specialist led, teacher led); and 4) '*the inclusion of Logan et al. (2018) operational definitions'* (four levels). Meta-analysis of FMS data was not possible due to the variability in measurement methods and reporting of outcomes.

We derived the threshold for minimal clinically important difference (MCID) for this study by using an anchor based approach using data from recent cross sectional (Deng and Fredrisken 2018) and longitudinal (Corder et al. 2015; Farooq et al. 2018; Jago et al. 2019) studies. Each of these studies reported daily changes in MVPA levels, measured using accelerometry, for each year of childhood. We used the reported daily change in MVPA levels from each of these studies to calculate the average decrease in MVPA per day, per year of age. We calculated that participation in MVPA decreases on average by 3.6 ± 0.5 minutes per day (mean ± SD), for each year of age across childhood (average across the aforementioned studies). Therefore, we define the MCID for this study as a mean difference of 3.6 minutes (intervention minus control) as any increase in MVPA above this amount could be considered as reversing the current decline in MVPA levels that occur throughout childhood.

In order to provide an expected range of the true effect (difference between intervention and control) occurring in future studies we calculated a 95% prediction interval (IntHout, Ioannidis, Rovers, Goeman (2016). Furthermore, using the methods described in Mathur and VanderWeele (2019), we calculated the proportion of future studies (with 95% CI) that are likely to achieve an effect that is above or below our threshold for a MCID.

3.3 Results

Searches of electronic databases yielded 22,866 articles. An additional 17 articles were identified from reference lists of eligible articles. Figure 3.1 provides the PRISMA flow diagram with reasons for study exclusion. Exclusion codes and their respective descriptions can be reviewed in Appendix B.

3.3.1 Participants

Eligible studies (n = 25 studies) were conducted across 305 primary schools/community centres with a combined population sample size of n = 11,822 (41% to 55% male; range). Participants were 5 to 11 years old (n = 25 studies), between 106 cm and 143 cm in height (n

= 13 studies) and weighed 19.3 kg to 49.9 kg (n = 11 studies). The percentage of participants classified as overweight/obese ranged from 21% to 46% overweight/obese (n = 9 studies).

Intervention participants (n = 5,831; 41% to 53% male) were 5.1 to 10.7 years old, 106 cm to 143 cm in height (n = 13 studies) and weighed 19.3 kg to 49.9 kg (n = 11 studies). Control participants (n = 5,355; 33% to 60% male) were 5.1 to 10.6 years old, 107 cm to 144 cm in height (n = 13 studies) and weighed 19.3 kg to 48.1 kg (n = 11 studies). Of the 25 eligible studies, 14 were suitable for meta-analysis (Appendix D) and contributed control and intervention data for minutes of MVPA for baseline and post study (mean ± *SD*); change scores (post – baseline; mean ± *SD*); or mean difference (95%CI; intervention – control). Meta-analysis was completed on n = 4,040 participants (Intervention n = 2,096; control n = 1,944) from 210 schools/community centres.

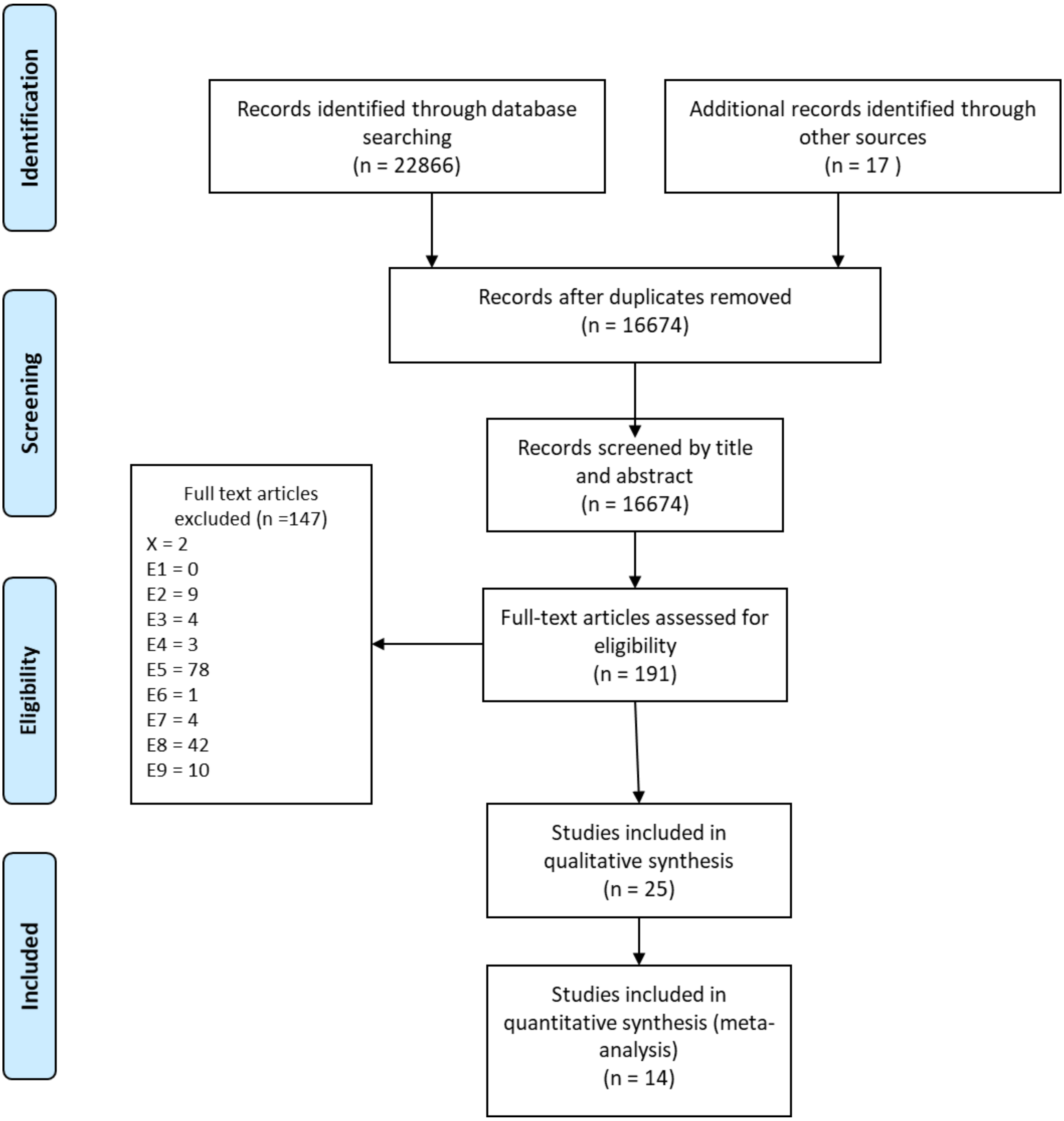


Figure 3.1 PRISMA Flow diagram with coded reasons for exclusion. Exclusion codes and reasons can be seen in Appendix B

3.3.2 Qualitative synthesis

Table 3.2 outlines the key characteristics of the studies included in this review. Of the studies included, 36% were conducted in Australia (n = 9) and 32% in the UK (n = 8), with three conducted in America, two conducted in Ireland and one each in Germany, Switzerland Greece. Included studies consisted of 19 RCT (n = 14 cluster; 5 parallel) and six non-RCT (parallel).

3.3.2a Fundamental movement skills

All the studies had FMS included in the physical activity component of their interventions. Of the 25 studies included, nine studies measured FMS at baseline and follow up using either; Test of Gross Motor Development (TGMD) 2.0 (Cohen et al. 2015; Johnstone et al. 2017; Morgan et al. 2018; Jago et al. 2019b), TGMD 3.0 (Morgan et al. 2018), Australian Department for Education manual (Salmon et al. 2008), the 'CHECK' test manual (Weber et al. 2017), the Process orient checklist (POC) (Bryant et al. 2016) or the Körper-koordination Test fűr Kinder (KTK) (Aivazidis, Venetsanou, Aggeloussis et al. 2019). Two studies reported skill scores for all three categories of FMS; Locomotor (LC), Object control (OC) and Stability/balance (B) (Bryant et al. 2016; Johnstone et al. 2019), three studies reported skill scores for two categories of FMS (LC, OC or LC, B) (Cohen et al. 2015; Johnstone et al. 2017; Weber et al. 2017; Aivazidis et al. 2019) and two studies reported OC skill scores (Nathan et al. 2017; Morgan et al. 2018). Overall FMS score was reported in five studies (Salmon et al. 2008; Cohen et al. 2015; Bryant et al. 2016; Johnstone et al. 2017; Johnstone et al. 2019). Of the nine studies measuring FMS, one study reported inter-rater agreement (Salmon et al. 2008), one study reported inter and intra-rater agreements (Bryant et al. 2016) and one study reported inter and intra-rater reliability coefficients (Kappa) (Cohen et al. 2015).

3.3.2b Physical activity

Measurement methods for physical activity and the associated data handling techniques from included studies can be seen in Table 3.3. Of the included studies, 18 used accelerometers, six used pedometers and one used a combination of pedometers and accelerometers (Table 3.3) with data presented as either step counts (pedometer), counts per minute (cpm) (accelerometer), percentage time spent in different activity thresholds (sedentary, light, moderate and vigorous, moderate-to-vigorous) (accelerometer), or minutes spent in each activity threshold (accelerometer). Of the 19 studies using accelerometers, 13 reported the cut points used for activity thresholds stated.

3.3.2c Outcome measurement and follow up

The duration of the intervention periods ranged from six weeks to four years. Of the 25 studies included, 12 studies collected initial outcome data within two weeks of the intervention finishing (Sallis et al. 1997; Cabaallero et al. 2003; Salmon et al. 2008; Barnes et al. 2015; Bryant et al. 2016; Wong, Ortiz, Stuff et al. 2016; Martin and Murtagh 2017; Nathan et al. 2017; Morgan et al. 2018; Taylor et al. 2018; Breslin, Shannon, Rafferty et al. 2019; Johnstone et al. 2019), three studies collected data between two weeks and three months (Sallis et al. 1997; Sutherland, Nathan, Lubans et al. 2017; Adab et al. 2018), six studies collected data during the final weeks of the intervention period (Kriemler, Zahner, Schindler et al. 2010; Jago et al. 2014; Fairclough et al. 2016; Weber et al. 2017; Johnstone et al. 2017; Jago et al. 2019b) and four studies did not report a time frame for outcome assessment (Morgan, Lubans, Callister et al. 2011; Cohen et al. 2015; ,Telford, Olive, Cochrane et al. 2016; Aivazidis et al. 2019). Follow up assessment was completed in nine studies (Salmon et al. 2008; Kriemler et al. 2010; Morgan et al. 2011; Jago et al. 2014; Barnes et al. 2015; Bryant et al. 2016; Martin and Murtagh 2017; Adab et al. 2018; Breslin et al. 2019), ranging from six weeks post intervention to three years post intervention.

Table 3.2 Summary of Interventions and characteristics of studies included in this review, in alphabetical order.

Study name	Intervention details	control group format	Study setting	Age (years)	Frequency Session per week	Intervention duration	Additional component	Intervention delivery method	Timing of initial outcome measurement	Follow up Timing and intervention outcome
Adab et al. 2018	Multi component - PA intervention components - School staff were provided with training and resources to provide 30 minutes of additional MVPA on each school day. Villa vitality - programme of activities based on movement routines and ball skills session, at an English premier league football club	Usual curriculum	Primary school	5 - 7	Villa Vitality = 3 sessions in total over one term (6 weeks) 30mins MVPA = Every school day in year 2, within school time	2 years	Cooking workshops; information sheets sent home to parents; Resources provided to teachers. Interactive nutritional sessions, and an opportunity to practise cooking skills	Coaching staff at Aston Villa FC, teachers at school (following training)	3 months post intervention	Yes; 6 months post Decrease in MVPA
Aivazidis et al. 2019	The "Walk" project – Organised PE, PA during recess and walking opportunities. PE lessons included movement activities aimed at developing FMS. Recess activities were organised games, with sports equipment	Usual curriculum	Kindergarten	5 – 6	PE lessons were ran 4 days per week for 45-50mins	1 school year (8 months)	Education sessions for teachers and parents and teacher training for developmentally appropriate PA	Classroom and PE teachers	Mid and End of intervention period _ no other details provided	No
Barnes et al. 2015	Multi component - Education sessions with 60 minute PA sessions Incl. rough and tumble play and fundamental movement skills	Wait list control	Primary school	5 - 12	1 x session per week for 8 weeks - 60mins PA - 25mins theory	8 weeks	Separate mother & daughter education sessions and PA homework	Researcher with PE qualification	2 weeks post intervention	Yes: 20 week follow up Decrease in MVPA
Breslin et al. 2019	Sport For LIFE:AI – Practical sport and PA sessions	Wait list control	Primary school	8 – 9	1 x 60mins per week	12 weeks	Not Applicable	Trained student volunteer from research institution	Midpoint (6 weeks) and immediately post (week 13)	Yes: 6 months post intervention Increase in MVPA – no diff between groups
Bryant et al. 2017	One PE lesson replaced with 1 x 45 minute lesson per week concentrating on skill development (Balance, throwing, catching, kicking, jumping, hopping, galloping)	Usual curriculum	Primary school	8-10	1 x 45mins per week	6 weeks	Not Applicable	Class teachers	Immediately post intervention (week following)	Yes; 12 weeks – data not available

Caballero et al. 2003	Multi component - PE program based on the SPARK - implementing a minimum of three 30-minute sessions per week of MVPA.	Not reported	Primary School	7 - 8	3x30mins SPARK sessions per week	3 years	Classroom curriculum - eating behaviours and PA. Nutritional advice for school meals. Family action packs	Regular delivery of PE (Some PE teachers, some classroom teachers)	3 years (immediately post intervention)	No
Cohen et al. 2015	Multi component - PA and FMS intervention - SCORES program 1: teacher professional learning & student leadership workshops. Implement 6 PA policies for promotion of PA and FMS within PE and school day.	Wait list control - Usual PE and school sport program	Primary school	7 - 10	Student workshop = 1 x 2 hour; Teacher workshop = 1 x full day & 1 x half day.	12 months	Strategies to target home environment (newsletter, parent evening). Strategies to improve school-community links	Teacher trained to deliver with pupils attending workshops to help lead sessions	12 months	No; 6 month mid review NA
Fairclough et al. 2016	1 x PE usual curriculum + 2 x BTM classes. The classes teach age appropriate movement skills designed to improve health related and skill-related fitness	Usual curriculum	Primary school	10 - 11	1x PE; 2 x BTM per week. 30-45mins per session (mean±SD; 43.6±2.2mins).	6 weeks	Not Applicable	Born to move specialist instructor (10 years' experience)	6 Weeks; outcomes assessed during intervention period	No
Jago et al. 2014	Action 3:30 After school PA programme - training teachers and assistants to deliver PA sessions following the FUNdamentals training programme to increase children's fundamental movement skills	No after school program	Primary school	9 - 10	2 x 60mins per week for 20 weeks (n=258/284 attended at least one session per week).	20 weeks	Not Applicable	Teaching assistant trained by Action3:30 researchers	20 weeks; outcomes assessed during intervention period	Yes; 4 month post intervention Decrease in MVPA
Jago et al. 2019b	Action 3:30R After school PA programme - training teachers and assistants to deliver PA sessions. Sessions focussed on fun PA whilst improving FMS	No after school program	Primary school	8 – 10	2 x 60mins per week for 15 weeks	15 weeks	Not Applicable	Teaching assistant trained by Action3:30 researchers	15 weeks; outcomes assessed during intervention period	No
Johnstone et al. 2017	The Go2Play Active Play intervention – structured games and free play with a variety of FMS www.Activeplay.org.uk	Usual curriculum	Primary school	6 - 8	1 - 2 x 60mins; 30mins structured games + 30 min free play per week	5 months	Not Applicable	Play workers from external company (www.agileCIC.com)	5 months from baseline; outcomes assessed during intervention period	No
Johnstone et al. 2019	Active play intervention (formally Go2Play) games designed to	Wait list control	Primary school	7 - 8	1 x 60 mins per week: 30mins	8 weeks	Not Applicable	Play workers from external company (www.agileCIC.com)	Immediately post intervention	No

	develop participants FMS www.actify.org.uk/activeplay				structured games + 30 min free play				(week following)	
Kriemler et al. 2011	Multi component - PE classes additional to current curriculum - The intervention group had two additional physical education lessons on the remaining school days in additional to current curriculum.	Usual curriculum	Elementary school	6 - 11	2 x 45mins PE per week in addition to 3 x 45min curriculum. 3-5 x 5 min/day PA breaks	9 months	3-5 breaks (2-5 mins) during academic lessons comprising movement skill tasks such as jumping or balancing on one leg. 10/min day PA homework (movement skill activities)	2 x 45 mins were delivered by specialist PE teacher. The 3x45 mins by standard classroom teacher	9 months; Outcomes measured over 3 weeks, during intervention period	Yes; 3 years post intervention Decrease in MVPA
Martin and Murtagh 2017	The Active Classrooms program behaviour change intervention to train and enable primary teachers to change their teaching methods toward engaging children in PA while learning the academic content of English and Mathematics lessons.	Wait list/delayed treatment	Primary school	8 – 12	2 x active lesson ideas per day. Minimum of 10 min per activity	8 Weeks	Not Applicable	Teacher trained	8 weeks; immediately post intervention	Yes; 8 weeks post intervention Increase in MVPA
Morgan et al. 2011	Multi component - The four major focus areas of the father/child PA sessions were (i) FMS (ii) rough and tumble play, (iii) health-related fitness and (iv) fun and active games	Wait list control	Community	5 - 12	8 weeks - 1 x 75mins PA per week (5 x dads only, 3 combined).	3 months	Education sessions for dads on healthy eating and behaviour change	Researcher with PE qualification	3 months from baseline	Yes; 6 months from baseline Step count increased
Morgan et al. 2014	Multi component - The four major focus areas of the father/child PA sessions were (i) FMS (ii) rough and tumble play, (iii) health-related fitness and (iv) fun and active games	Wait list control	Primary school	5 – 12	7 weeks - 1 x 90mins PA per week (4 x dads only, 3 x combined).	7 weeks	Education sessions for dads on healthy eating and behaviour change	Trained PE teachers	6 weeks post intervention (no contact with participants weeks 8-14)	No
Morgan et al. 2018	The programme engaged Dads and Daughters in fun, PA targeting rough and tumble play, sport skill, FMS and aerobic and muscular fitness.	Wait list control	Community (delivered in local University)	5 - 12	8 weeks - 1 x 90mins PA per week.	8 weeks	Educational component for fathers, daughters and families. Resources were provided to fathers, daughters and families	Members of the research team	2 months (week following final sessions)	No
Nathan et al. 2017	The Great Leaders Active StudentS (GLASS) program – Student leaders were placed in groups and attended FMS sessions for 10 weeks. Additional FMS sessions	Usual curriculum	Kindergarten & Elementary school	5 – 8	2 x 30mins per week	10 weeks	Not Applicable	10-11 year old peer leaders	10 weeks (immediately post intervention)	No

	with 18 FMS equipment packs provided were provided.									
Sallis et al. 1997	2 arm PE intervention (delivery type) - SPARK PE. A typical SPARK lesson had two parts: health-fitness activities and skill-fitness activities	Usual curriculum	Primary school	9 - 10	3 x 30mins per week (15mins x HRF, 15mins x Skill)	2 years	Not Applicable	Arm 1 - specialist led, Arm 2 - teacher led	Measures taken at the end of each year	No
Salmon et al. 2008	FMS intervention focused on six skills, including three object control skills (overhand throw, kick and strike) and three locomotor skills (run, dodge and vertical jump). Most lessons focused on at least two skills, and each skill was a focus in at least six or more sessions	Usual curriculum	Primary School	10 – 11	19 x 40-50mins once per week	19 weeks	Not Applicable	PE teacher	19 weeks (immediately post intervention)	Yes; 6 and 12 months follow up Decrease in MVPA
Sutherland et al. 2017	Multi component - Teaching strategies to improve PE lesson quality. Schools were provided with PA equipment and encouraged to offer supervised PA at breaks. Sixth-grade students were encouraged to become school PA leaders and set up, run, and pack away games. All classroom teachers were offered a 90-minute professional learning workshop focused on delivery of FMS to students, strategies to improve lesson quality through student engagement and increase students' MVPA.	Usual curriculum	Primary school	9 - 11	Student workshop = 1 x 2 hour; Teacher workshop = 1 x full day & 1 x half day.	6 months	School PA policy review and parental engagement through newsletter and school website promotion. Improvements to community links	Peer teaching with experienced health promotion staff with PE background. Teachers were trained in line with SAAFE principles	6 months; over the course of 3-4 months	No
Taylor et al. 2018	Multi component – PA included Active breaks (AB), bounce at the bell, 'Born To Move' (BTM) and PA playground challenge cards.	Usual curriculum timetabled breaks	Primary School	9 - 10	AB = 1 x 5mins per day. Bounce at the bell = 3 x 1-2mins per day. BTM = 2 x 10mins per week. Playground cards = 5 min/game every break time.	8weeks	PA homework and newsletters. The Daily mile (1 x 15 min per day). Teacher training.	Sports coach or PE teacher normal delivery	2 months; (week following final sessions)	No

Telford et al. 2016	The Intervention consisted Fitness, coordination and Agility; Gymnastic-based activities; Skill activities including group and individual practices to develop movement skills; Games designed to promote aerobic fitness, cooperation and teamwork; Core movement including yoga-like practices to develop muscular strength, flexibility, balance and postural control	Usual curriculum	Primary school	8 - 12	2 x 45mins per week over 4 years (68 lessons per year). The 90mins per week was added to the remaining curriculum taught PE to make up the 150mins per week. lesson time = game play 28 ± 12 mins; fitness activities 12 ± 10mins; skill practice 8 ± 8mins; core movements 5 ± 5mins	4 years (data collected at the end of each year)	Not Applicable	Five university qualified PE teachers training from Blue-earth	End of intervention period _ no other details provided	No
Weber et al. 2017	Multi-component - "Fitness Fur Kids" - exercise program with extensive movement training and high levels of MVPA	Not reported	Primary school	9 - 10	2 x 45mins additional PE sessions per week using the Fitness Fur Kids plans	10 months	Diet - 10 school lessons (1/month) related to nutrition. Extra-curricular - soccer training session, visits from local/national sports teams.	Physical component taught by qualified trainers	Mid intervention only at 6 months	No
Wong et al. 2016	Multi-component - after school - The intervention group received structured PA- using: hurdles, BOSU balls, jump ropes, medicine balls, obstacle course, broom balls, urban rebounders, team resistance rings, agility rings, cone drills, hula hoops, soft foam balls, agility ladders, reaction balls, parachute play	Regular after school programs	Community centres	9 - 12	2 x 90mins/week for 6 weeks (then repeated)	3 x 6 week blocks	30 minutes of theory twice per week. intervention group completed a final block of water based activity	Trained program staff	Measurements taken at the end of each 6 week block	No

BTM = born to move; FMS = fundamental movement skills; HRF = health related fitness; MVPA = moderate to vigorous physical activity; PA = physical activity; PE = physical education; SAAFE = supportive, active, autonomous, fair, enjoyable; SCORES = supporting children's outcomes using rewards, exercise and skills; SPARK = sports, play and active recreation for kids

Table 3.3 Physical activity measurement methods and FMS tools used in the studies included in this review.

Study	PA measurement method	MVPA Output	Cut points used for activity thresholds	Measured FMS	FMS tool used	FMS outcomes
Adab et al. 2018	Accelerometer (uniaxial)	Minutes MVPA	Not reported	No	NA	NA
Aivazidis et al. 2019	Pedometer	Step count	NA	Yes	KTK	LC, B skill score
Barnes et al. 2015	Accelerometer (triaxial)	CPM	SED 0-100; LPA 101-2292, MPA 3581-6129; VPA >6130cpm †[2]	No	NA	NA
Breslin et al. 2019	Accelerometer (triaxial)	Minutes MVPA	MPA 2293-4008; VPA >4008cpm †[5]	No	NA	NA
Bryant et al. 2017	Pedometer	Step count	<1000 AND >40000 steps excluded	Yes	POC	LC, OC, B skill score and overall FMS
Caballero et al. 2003	Accelerometer (triaxial)	CPM	Not reported	No	NA	NA
Cohen et al. 2015	Accelerometer (triaxial)	Minutes MVPA	SED 0-100; LPA 101-2292, MPA 2293-4008; VPA >4008cpm †[2]	Yes	TGMD 2	LC, OC skill score and FMS overall
Fairclough et al. 2016	Accelerometer (triaxial)	Minutes MVPA	SED <113; LPA 306-817; MPA = 818-1968, VPA >1969, MVPA = >818 †[3]	No	NA	NA
Jago et al. 2014	Accelerometer (triaxial)	Minutes MVPA	SED 0-100; LPA 101-2292, MPA 2293-4008; VPA >4008cpm †[2]	No	NA	NA
Jago et al. 2019b	Accelerometer (triaxial)	Minutes MVPA	SED 0-100; LPA 101-2292, MPA 2293-4008; VPA >4008cpm †[2]	No	NA	NA
Johnstone et al. 2017	Accelerometer (triaxial)	CPM	SED 0-100; LPA 101-2292, MPA 2293-4008; VPA >4008cpm †[2]	Yes	TGMD 2	LC, OC Skill score, FMS overall and GMQ
Johnstone et al. 2019	Accelerometer (triaxial)	% time spent in	SED 0-100; LPA 101-2292, MPA 2293-4008; VPA >4008cpm †[2]	Yes	TGMD 2	LC, OC Skill score, FMS overall and GMQ
Kriemler et al. 2011	Accelerometer (uniaxial)	Minutes MVPA	Not reported	No	NA	NA
Martin and Murtagh 2017	Accelerometer (triaxial)	Minutes MVPA	SED 0-100; LPA 101-2292, MPA 2293-4008; VPA >4008cpm †[2]	No	NA	NA

Morgan et al. 2011	Pedometer	Step count	NA	No	NA	NA
Morgan et al. 2014	Pedometer	Step count	NA	No	NA	NA
Morgan et al. 2018	Pedometer	Step count	NA	Yes	TGMD 2 and 3	OC Skill score
Nathan et al. 2017	Pedometer	Step count	NA	Yes	TGMD 3	OC skill score
Sallis et al. 1997	Accelerometer (uniaxial)	CPM	Not reported	No	NA	NA
Salmon et al. 2008	Accelerometer (uniaxial)	Minutes MVPA	LPA <1951; MPA 1952-5724; VPA>5725 †[1]	Yes	Australian dept. for ed.	FMS overall – GMQ z score
Sutherland et al. 2017	Accelerometer (triaxial)	Minutes MVPA	SED 0-100; LPA 101-2292, MPA 2293-4008; VPA >4008cpm †[2]	No	NA	NA
Taylor et al. 2018	Accelerometer (triaxial)	Minutes MVPA	Vector magnitude, measured in m*g* – SED <50m*g*; LPA 51-200m*g*; MPA 201-706m*g*; VPA	No	NA	NA
Telford et al. 2016	Accelerometer (uniaxial) and Pedometer	Minutes MVPA	SED 0-100; LPA 101-2292, MPA 2293-4008; VPA >4008cpm †[2]	No	NA	NA
Weber et al. 2017	Accelerometer (uniaxial)	Minutes MVPA	Not reported	Yes	CHECK test	LC, OC skill scores and CHECK mean score
Wong et al. 2016	Accelerometer (triaxial)	% time spent in	Not reported	No	NA	NA

†[1] – Freedson et al. (2005); †[2] - Evenson et al. (2008); †[3] - Chandler et al. (2016); †[4] - Hildebrand et al. (2014); †[5] – Mattocks et al. (2007); MVPA = Moderate to vigorous physical activity; FMS = Fundamental movement skills; NA = Not applicable; LC = Locomotor; OC = Object control; B = Balance; SED = Sedentary; LPA = Light physical activity; MPA = Moderate physical activity; VPA = Vigorous physical activity; CPM = counts per minute; KTK = Körper-koordination Test fűr Kinder; POC = Process orient

3.3.3 Risk of Bias

The summary of the risk of bias assessment for RCT and non-RCT studies are presented in Figure 3.2 and Figure 3.3, respectively. Individual scores for risk of bias can be observed in Appendix C. The bias domain which resulted in most of the 'high risk' classifications was section 3 and 4 of the RoB2.0 and section 4, 5 and 6 of the ROBINS-I assessments. In both cases these sections relate to the assessment of bias due to missing outcome data and measurement of the outcome. Eight studies scored as either 'some concerns/moderate' or 'high/serious risk' of bias due to the handling of missing data and not blinding outcome assessors. Baseline imbalances, due to either the randomisation process (RoB2.0) or not controlling for confounders (ROBINS-I) was responsible for two RCT and three non-RCT studies scoring as either 'some concerns/moderate' or 'high/serious risk' of bias. One RCT scored 'high risk' for multiple analyses of the data, however this score was given as it was hard to gain clarification due to data protection laws prohibiting access (Caballero et al. 2003). Of the 25 studies included 40% (n = 10) received an overall score of 'low risk'.

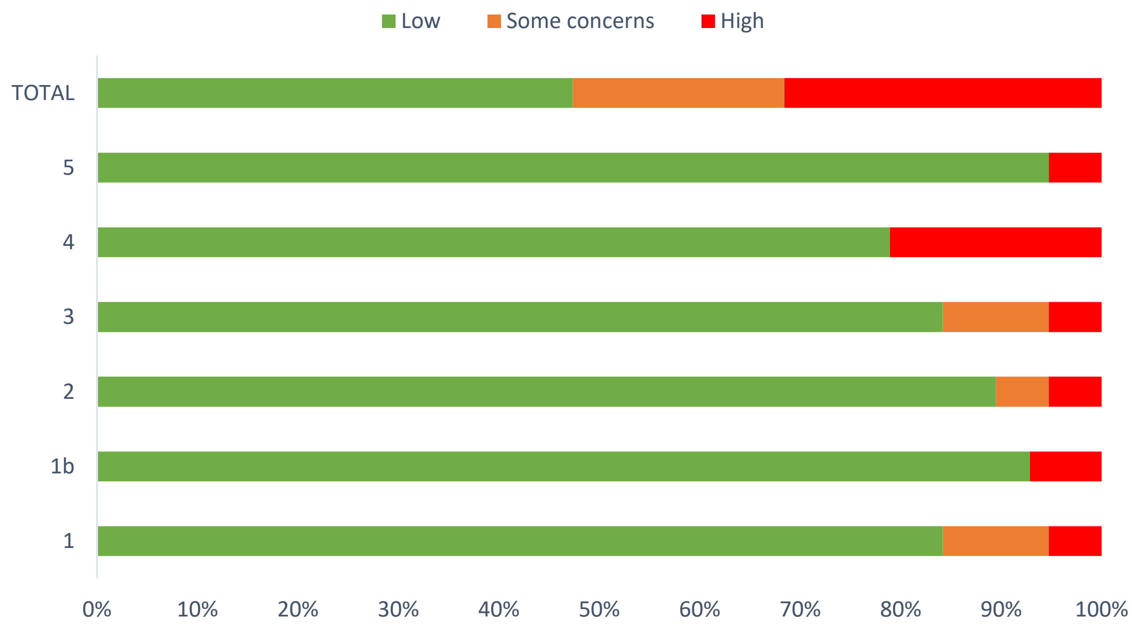


Figure 3.2 Risk of Bias assessment for Randomised Control Trials; 1) Bias arising from the randomization process; 1b) Bias arising from the timing of identification and recruitment of individual participants in relation to timing of randomization (ONLY CLUSTER RCT); 2) Bias due to deviations from intended interventions; 3) Bias due to missing outcome data; 4) Bias in measurement of the outcome; 5) Bias in selection of the reported result

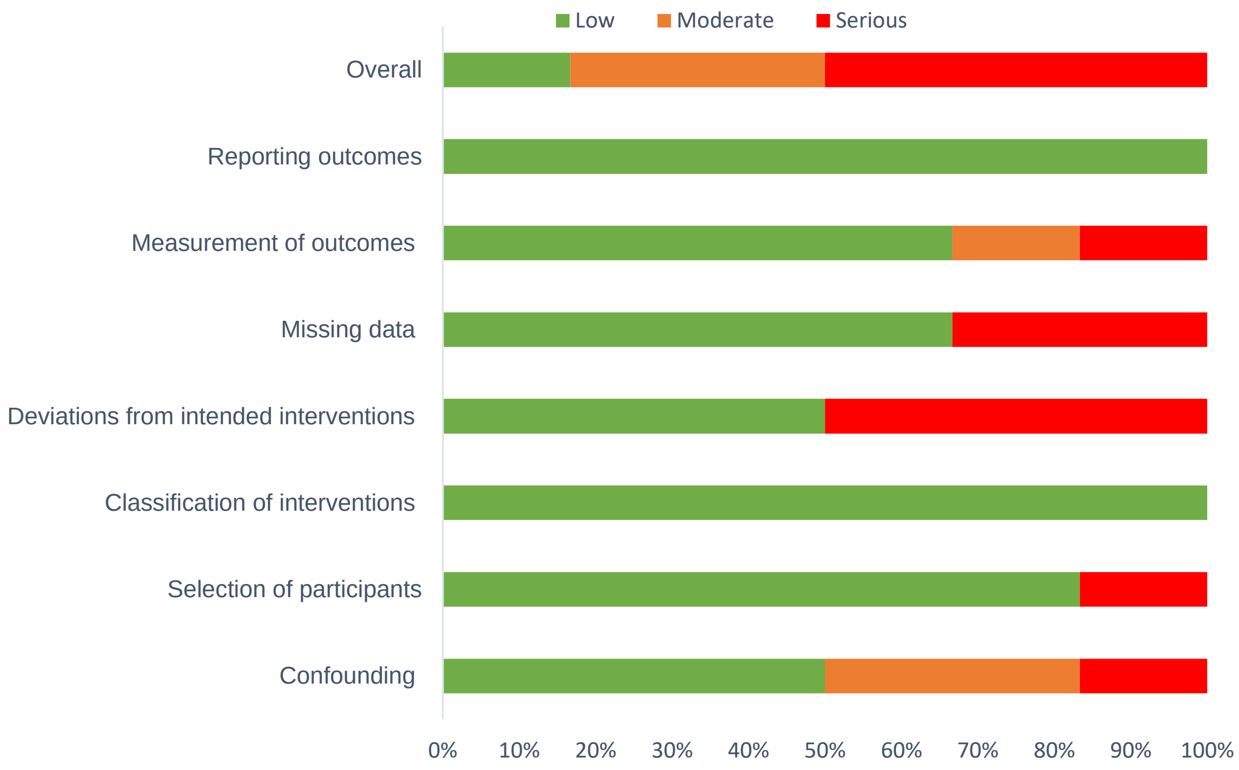


Figure 3.3 Risk of Bias assessment for Non-Randomised Controlled Trials

3.3.4 MVPA Data synthesis

Random effects meta-analysis resulted in a pooled mean difference of 4.3 minutes (95%CI; -0.3 to 8.8) in favour of the intervention group. The between study variability, expressed as Tau (T), was 7.6 minutes. The 95% prediction interval; the effect that is likely to be expected in a future study was -13 to 21 minutes. The percentage of future studies that are likely to be above our MCID threshold of 3.6 minutes of MVPA is 47% (95%CI; 22 to 70) with a percentage of future studies that are likely to find an effect below 3.6 minutes of 15% (0 to 39). Publication bias due to possible small study effects was evident on examination of the funnel plot (SE/mean difference) with an Egger's regression coefficient of 1.8 (95%CI, -0.7 to 4.4), with smaller studies having the largest treatment effects and a higher number favouring the control/alternative treatment group.

3.3.5 Meta-regression

Model 1

Exploratory Meta-regression analyses revealed a coefficient (difference in means) of 12.8 minutes of MVPA per day (95%CI; 6.5 to 19.1; p = 0.0011) in favour of the studies that fully embody the concept of FMS (combining a measure of FMS with Logan et al. (2018) criteria), with an improvement in study heterogeneity (Ƭ = 2.9 minutes). A significant effect was found for model one (F = 9.3, df = 3, dfErr = 10, p = 0.0031), explaining 85% of the variability between studies (R^2 = 0.85). (Appendix D).

Model 1 equation: If a measure of FMS used with at least one of Logan et al. (2018) criteria

Intercept = 1.5772

Y = 1.5772 + 12.8205

Model 2

Meta-regression examining the use of Logan et al. (2018) three criteria revealed an additive effect (linear increase) for the number of criteria used. The use of at least one criteria had a negligible effect on minutes of MVPA (-0.09 min/day; -5.8 to 5.7; p = 0.97), whilst the use of two (9.5 min/day; 1.4 to 17.6; p = 0.03) and three (15.7 min/day; 8.9 to 22.6; p = 0.0004) had a substantial effect on minutes of MVPA. A significant effect was found for model 2 (F = 11.2, df = 3, dfErr = 10, p = 0.0016), explaining 89% of the variability between studies (R^2 = 0.89). Model 2 also resulted in a reduction in between study variability (Ƭ = 2.5 minutes). (Appendix D)

Model 2 equation: Intercept = 1.1815

If one Logan et al. (2018) criteria used; Y = 1.1815 – 0.0920

If two Logan et al. (2018) criteria used; Y = 1.1815 + 9.5185

If three Logan et al. (2018) criteria used; Y = 1.1815 + 15.7346

Additional models

Instructor type (R^2 0.1; Ƭ = 7.2) and the use of multicomponent interventions (R^2 = 0.0; Ƭ = 8.0) did not explain any of the between study variance. Meta-regression using study quality as a moderator was deemed inappropriate due to the low number of studies in each category.

3.4 Discussion

Fundamental movement skills are considered an important prerequisite for physical activity participation (Barnett et al. 2016a). This systematic review and meta-analysis aimed to establish the effectiveness of FMS interventions at improving daily MVPA levels in primary school children. A key finding was that we observed FMS interventions to improve daily levels of MVPA by 4.3 minutes/day (pooled effect), exceeding the MCID threshold set for this study (3.6 minutes/day). This indicates that the inclusion of an FMS intervention is likely to improve children's daily levels of MVPA. However, the intervention effects varied considerably between the 14 studies (range -16 to 18 minutes between group differences). The typical between study variability (Tau) of 7.6 minutes MVPA shows the substantial heterogeneity, and results in wide prediction intervals for future studies. Meta-regression identified studies that included both a measure of FMS and a minimum of one criteria from Logan et al. (2018) operational definition of FMS reduced the between study variability (tau) to 2.9 minutes and increased the effect size to 12.8 minutes/day.

Very few of the studies included in the meta-analysis of MVPA measured FMS as an outcome variable (n=4). Of the 25 studies included in the qualitative synthesis, nine measured FMS as an outcome (Table 3.2) and seven reported positive effects of the FMS intervention on physical activity outcomes. For studies to include a measurement of FMS implies that the intervention designers in the aforementioned studies have an understanding that the mastery of FMS goes beyond the phylogenetic development of a child's physical growth (Barnett et al. 2016a) and therefore are likely to have put a larger emphasis on providing developmentally and instructionally appropriate FMS activities (Logan, Robinson, Wilson et al. 2012). Including at least one of the recommended criteria leads one to infer that the authors of these studies identified a need to be explicit in their understanding of FMS. This point is supported further by the outcomes from the categorical (4 levels) meta-regression exploring the effect of including an operational definition of FMS using the three criteria set out in Logan et al. (2018). If no criteria were used (Intercept/level1) there was an expected effect of 1.18 minutes with a trivial (-0.09) decrease expected if only one criteria were used. However, if two or three criteria were used, meaning the authors fully conceptualised FMS, then there was an expected increase of 9.52 and 15.7 minutes of MVPA, respectively. It should be noted here that these data are exploratory, and due to a small number of studies using a measure of FMS or Logan et al. (2018) criteria, cautious interpretation is advised (Cheung 2019).

Including FMS activities without an explicit understanding and with the false expectation that children will naturally become proficient, ignores much of the evidence surrounding the delivery and instruction of FMS. Incorporating traditional FMS activities (e.g., jumping, throwing) without explicit teaching or coaching, with the hope children will improve naturally over time disagrees with the pedagogical research surrounding FMS (Gallahue et al. 2012; Logan et al. 2012; Iivonen and Sääkslahti 2013; Barnett et al. 2016a). The development of FMS is analogous to the way a child learns to read and write (Gallahue et al. 2012). Without prior teaching of letters and their phonemes, children are less likely to be able to structure more complex words and sentences. Similarly, children who do not develop the most basic FMS are unlikely to possess the movement repertoire necessary when faced with more demanding tasks. Moreover, providing children with free-play opportunities and providing games equipment does not have an automatic consequence of improved FMS (McKenzie et al. 1998; Logan et al. 2012; Barnett et al. 2016a), in the same way providing children with a library of books does not result in an advanced reading ability.

A review by Lubans et al. (2010) found strong evidence for a positive association between FMS competency and physical activity in children and adolescents. However, the limited number of studies in Lubans et al.'s review resulted in a combined data set for children and adolescents, therefore, could not differentiate between the childhood and adolescent importance of FMS for physical activity participation. The age range of participants included in our meta-analysis was 5 to 11 years of age, highlighting the importance of FMS for physical activity participation in primary school children. Supplementary to the pooled intervention effect in this meta-analysis, we estimated that half of all future studies (47%) should expect to find an effect greater than the MCID, emphasising the potential for FMS interventions to increase childhood levels of MVPA.

Our results agree largely with recent reviews (Naylor, Nettleford, Race et al. 2015; Engel et al. 2018) regarding the variability in intervention implementation. There was substantial variability in the methods utilised in the interventions of included studies in this review (Table 3.2). Firstly, there was disparity in the number (multi-component) and type of components in the interventions with 12 of the 25 included studies reporting the use of a multicomponent intervention. Secondly, the level of instruction varied considerably between studies, reporting the use of either the schoolteachers (teacher led), school pupils (peer led) or specialist PE teachers/coaches. However, meta-regression using instructor type ([specialist led; Salmon et al. 2008; Fairclough et al. 2016; Telford et al. 2016; Weber et al. 2017; Adab et al. 2018; Johnstone et al. 2019; Breslin et al. 2019], [teacher led; Kriemler et al. 2010; Jago et al. 2014; Martin and Murtagh 2017; Sutherland et al. 2017; Taylor et al. 2018; Aivazidis et al. 2019]) and the use of multicomponent interventions (Kriemler et al. 2010; Cohen et al. 2015; Telford et al. 2016; Weber et al. 2017; Adab et al. 2018; Aivazidis et al. 2019) did not explain any of the heterogeneity between studies. This is contrary to findings from a recent review (Engel et al. 2018), which reported study heterogeneity was reduced when studies were conducted by an FMS specialist three or more times per week for six months. This contrast in findings implies that the inclusion of an FMS specialist instructor is not enough on its own to improve FMS and physical activity levels, rather it is the combination of an FMS specialist and the appropriate volume and duration of the intervention components (Engel et al. 2018).

The aforementioned insights are important when considering the design of an FMS intervention. However, Engel et al. (2018) were unable to quantify the effect of FMS interventions on daily levels of MVPA in primary school aged children. The MVPA effects presented by the authors are inclusive of both preschool and primary school age studies. Further Engel et al. (2018) grouped studies focussing on overweight populations with studies without a specific focus on weight status. Lastly, the authors combined outcomes from studies using different MVPA measurement tools (accelerometer, pedometers and observation) and time frames (class time only, school day and whole day) in their analyses. Although an attempt was made to meta-analyse studies by using the standardised mean difference (SMD), this does not account for study differences that are a result of the strong moderating effects of age and weight status in the FMS/physical activity relationship, previously identified in the literature (Barnett et al. 2016b). The use of SMD in meta-analysis has also been criticised due to common disagreements in data extraction and high rates of errors, often resulting in outcomes that negate the findings of the analyses (Gøtzsche et al. 2007; Tendal et al. 2009). Our study excluded articles which had a specific focus on a single population group (overweight/obese, developmental disorders) and pre-school aged children. Furthermore, we only included studies in our meta-analysis that reported daily levels of MVPA in minutes per day, enabling us to explore the absolute difference in means and avoid the errors associated with SMD. Despite the heterogeneity noted in our study, the results add to the positive relationship between FMS and daily levels of MVPA.

The heterogeneity established in this review may be further explained by the biases present in the reporting of study outcomes. Studies included in this review were identified as having biases due to 1) the contamination of groups; 2) blinding of assessors; and 3) the handling of missing data. We agree with Engel et al. (2018), that the blinding of participants in an intervention study is not always possible and in younger age groups is unlikely to have an effect on the outcome. In our study, articles including parent/child dyads (Morgan et al. 2011; Morgan, Collins, Plotnikoff et al. 2014; Barnes et al. 2015; Morgan et al. 2018) were scored at a high risk of bias in this domain, due the parent's ability to identify their participation in a study and allocated group; which reflected on the results of their self-reported outcomes. Although meta-regression using study quality as a moderator was not possible due to small number of studies in each category, we advise caution when interpreting results from studies with subjective measures that did not blind outcome assessors.

The reliability of assessors using measures of a subjective nature (i.e., FMS measurement) is an area of important focus. Poor rater reliability can over or underestimate the actual effect of the intervention. Barnett et al. (2009) identified that certain skills in a battery of FMS tests are more problematic to assess, therefore, the type of skills measured in the measurement battery chosen is likely to elicit different results dependent on the reliability of the assessors. Of the nine studies that measured FMS, all measured FMS subjectively, however, only one reported interrater and intra-rater reliability for the baseline and outcome assessors.

3.4.1 Future Recommendations for reporting of outcomes

Sixteen studies in this review neglected to include a measure of FMS, supporting earlier criticism from Logan et al. (2018) that a large proportion of the contemporary literature fails to adequately interpret the definitions and characteristics of FMS. Furthermore, when referring to Logan's recommended criteria for an operational definition of FMS, seven of the 25 studies included in this review documented one of the three definitions (Cohen et al. 2015; Jago et al. 2014; Nathan et al. 2017; Morgan et al. 2018; Johnstone et al. 2019; Jago et al. 2019) and three studies were recorded as including all three FMS criteria (Salmon et al. 2008; Cohen et al. 2015; Nathan et al. 2017). We reinforce these recommendations, and advise future studies including FMS to include an operational definition of FMS, incorporating specific skill categories and specific examples of FMS relevant to the study, as highlighted in Logan et al. (2018). In agreement with earlier research recommendations (Barnett et al. 2009), we emphasise the necessity for studies to present their inter-rater and intra-rater reliability for any subjective assessments. Further confidence in study outcomes would be established by presenting reliability data for assessors for each skill domain for FMS (object control, locomotor and balance) and the individual skill scores (Barnett et al. 2009).

Future studies should equally consider the effect of completing outcome assessments during the intervention period, particularly inclusive of days when the intervention sessions took place. Of the 25 studies included, six studies completed outcome assessment during the intervention period (Kriemler et al. 2010; Jago et al. 2014; Fairclough et al. 2016; Johnstone et al. 2017; Weber et al. 2017; Jago et al. 2019). The MVPA levels reported in these studies is likely due to the increased activity levels of the children during the intervention sessions, and not a true representation of the intervention effect.

Furthermore, the duration of time taken to complete outcome assessment ranged from one week to three months with a proportion of studies (36%) completing follow up assessments (Table 3.2). Timing of outcome measurements is important from a movement development perspective. Outcomes assessed immediately following the completion of the intervention (post-test) represent an immediate motor learning response (*'performance'*) (Barnett et al. 2009) to the FMS activities included in the intervention, particularly in studies of relatively short durations (six to eight weeks). Follow up measures, often used as a retention test when measuring FMS, evaluate more permanent results in the movement *'development'* (Vernadakis, Ppastergiou, Zetou et al. 2015) of the child. However, of the nine studies in this review completing follow up assessments, only two measured FMS at post-test and follow up (Salmon et al. 2008; Bryant et al. 2016). For this reason, ascertaining a relationship between true FMS *'development'* and MVPA levels would be erroneous. Future studies should consider including both an FMS *'performance'* and FMS *'development'* evaluation alongside objectively measured MVPA to acquire a greater understanding of the relationship between FMS and MVPA over time.

Finally, the different placement of the accelerometers to measure physical activity in the included studies in addition to the variety of cut-points used might have contributed to mixed findings concerning the contribution from the FMS in the intervention activities. Traditionally accelerometer cut-points are derived from sedentary (supine and seated) and locomotion type activities with accelerometers worn at the hip; however, ankle worn accelerometers (with associated cut-points) has recently been shown to provide a more suitable location to quantify moderate physical activity in primary school aged children (Duncan et al. 2019). Future studies measuring the effect of FMS activities on physical activity levels in children should consider using appropriate standardised methods for the placement of measurement devices and associated, validated cut-points.

3.4.2 Strengths and limitations

This review complied with a predefined study protocol (Prospero) and employed a comprehensive search strategy, a thorough selection and screening strategy and adhered to the PRISMA protocol for systematic reviews (Liberati et al. 2009). There was substantial heterogeneity noted, resulting in wide confidence intervals and large between study variability, therefore; as for most meta-analysis, caution is warranted in interpreting the prediction intervals presented (Franklin, Atkinson and Batterham 2019). The heterogeneity noted also disguises the fact that there are large effect sizes in some of the studies included (Weber et al. 2017). For this reason, we applied contemporary metrics (Mathur and VanderWeele 2019), which express the estimated proportion of future studies with expected effects above and below a defined threshold, in this case the MCID of 3.6 minutes of MVPA. Meta-regression identified that studies which accurately conceptualised and measured FMS substantially improved the intervention effect with reduced heterogeneity. However, caution in interpretation of results should be applied due to the small number of studies included in the analyses (Higgins and Green 2011; Cheung 2019). Furthermore, the authors acknowledge that the restrictive word counts of journals who published the articles that were included in this systematic review may have limited a detailed definition of FMS in their narrative. In future, a more exploratory method of identified and categorising the quality of FMS intervention used in a meta-regression is advised.

Eggers regression coefficient and its uncertainty revealed a possible small study bias, with smaller studies resulting in larger individual study treatment effects and also having a higher number of studies favouring the control group. However, caution is advised when interpreting these small study effects due to the aforementioned heterogeneity noted in this meta-analysis. Finally, the decision to include only studies that reported daily minutes of MVPA may have underestimated the true effects on physical activity (i.e. total physical activity) of a FMS intervention in this population. However, the incongruity in the reporting of physical activity outcome data (Table 3.3) was considered problematic and would only serve to obscure the relationship between physical activity levels and FMS competence.

3.5 Conclusion

Based on the results of this meta-analysis and narrative synthesis, the inclusion of FMS activities to a physical activity intervention aiming to improve daily levels of MVPA in 5 to 11 year old children is advocated. However, we conclude that comparable future studies focussing on FMS interventions should concentrate on establishing an accurate conceptualisation of FMS and how FMS will be integrated within their interventions. This would likely enhance study outcomes. Furthermore, including a measure of FMS at regular intervals throughout the intervention would serve to potentially reverse the current decline in physical activity levels observed during childhood. Though this may seem time consuming from a school resource perspective, it would ensure that the included activities for the duration of the intervention period (or school term/year) are developmentally appropriate and accompanied with the relevant level of instruction and coaching. Adequate consideration should also be given to the research design, methods used to evaluate FMS, and an appropriate follow up period.

3.6 PhD implications

The findings from this meta-analysis have important implications when prescribing intervention activities designed to encourage a higher level of physical activity in primary school children.

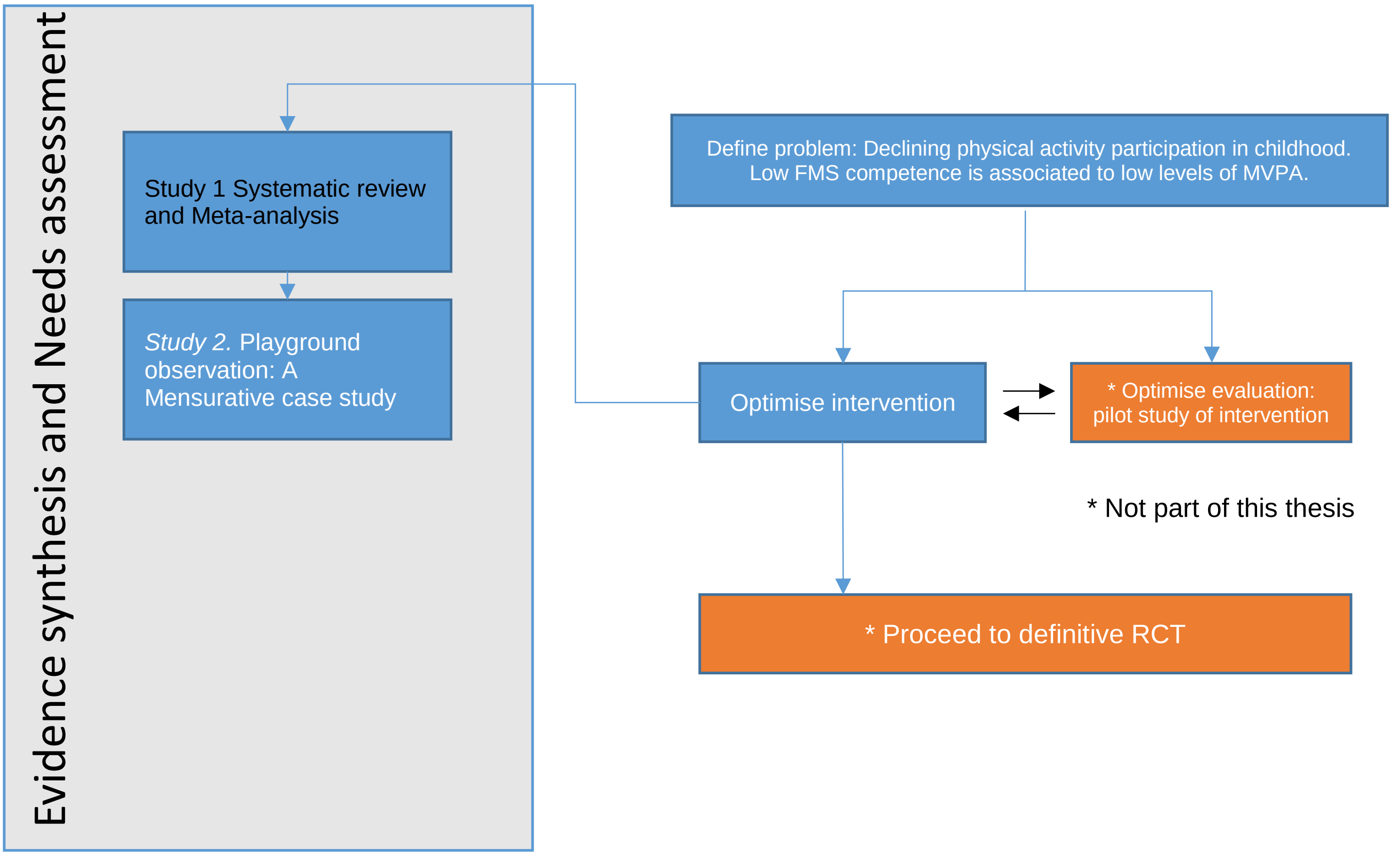
Firstly, the inclusion of FMS activities in any future physical activity intervention would encourage a higher amount of MVPA, at least during and immediately following the intervention. However, longer term effects on MVPA are unclear due to the few studies measuring outcomes at follow up.

Children with a higher level of FMS competence would be able to better explore the physical environment of the playground and develop skills which could be transferred to other free-living activities. A foundation level of FMS competence could be encouraged through structured sessions such as PE and extra-curricular clubs. Exercises and activities included in any research driven physical activity intervention should be designed to develop children's FMS competence. It would also be beneficial, both at a research and a practical level, to measure FMS competence during a baseline period (i.e., pre-intervention or beginning of each school year) and at regular follow up intervals to ensure an appropriate level of FMS are being instructed/developed.

FMS interventions in this chapter have explored a number of different environments (Sports clubs: Adab et al. 2018, PE lesson: Sallis et al. 1997; Caballero et al. 2003; Kriemler et al. 2010; Bryant et al. 2016; Fairclough et al. 2016, Classroom based: Martin and Murtagh 2017, Afterschool: Jago et al. 2014; Wong et al. 2016; Jago et al. 2019, Community based: Morgan et al. 2011; Morgan et al. 2018), however, FMS interventions focused on the playground alone are lacking.

Very few of the included studies in this chapter had a focus on break-times and the school playground. Those that included the promotion of physical activity during break-times did not consider the effect of implementing intervention components on the already more active areas of the playground, potentially leading to decreases in MVPA during break-time. Therefore, observations of the primary school playground in its current configuration are required to better understand the areas of the playground that children choose to visit at break-times and current hotspots for MVPA. Systematic observation of the playground will help explore the contextual physical activity mediating variables (for example; equipment provision, supervision, accessibility) present in the various playground areas, whilst identifying the FMS requirements for effective playground use and examining the physical characteristics (size, surface type, structures) of the areas which currently promote a higher level of physical activity during break-times. Understanding the primary playground environment and dynamics will allow for a more successful integration of future physical activity interventions focussed on the playground.

CHAPTER 4: THE SCHOOL PLAYGROUND ENVIRONMENT AS A DRIVER OF PRIMARY SCHOOL CHILDREN'S PHYSICAL ACTIVITY BEHAVIOUR: A MENSURATIVE OBSERVATIONAL CASE STUDY OF A PRIMARY SCHOOL IN THE TEES VALLEY



Chapter aim: Identify playground areas that promote the highest number of MVPA episodes during school break and lunch-times. Evaluate the effect of environmental and contextual factors on the proportion of MVPA episodes observed. Explore gender preference for playground areas

Study design: Cross-sectional using direct observation

Key points: Low levels of MVPA were observed during break-times. Playground areas promoting climbing, team sports and adventure play promote higher levels of MVPA at break-times. Consideration should be given for the inclusion of adult supervision and organisation; and to the provision of age/developmentally appropriate equipment. Team sports and climbing areas had a higher number of male and female children occupants, respectively. Implications of these findings to future interventions can be seen in chapter 7 and 8.

4.1 Introduction

Physical activity is associated with numerous health benefits in school-aged children (Strong et al 2005), with higher amounts of physical activity promoting more benefits (Janssen and LeBlanc 2010). Current recommendations suggest that children and young people should engage in moderate to vigorous intensity physical activity (MVPA) for an average of 60 minutes a day over the course of the week (DoH 2019). However, accelerometry measured physical activity data from 770 school children highlighted that 49% of males and 76% of females aged 4 to 10 years old have previously failed to meet the earlier MVPA recommendations in England of at least 60 minutes per day (HSE 2008). Furthermore, accelerometer data from the millennium cohort study show less than 50% of primary school children achieved the recommended levels of physical activity (Griffiths et al. 2013).

In order to increase physical activity levels of children, a number of initiatives have been designed and delivered in the UK and across the world with varied successes (Eather et al. 2013; Barnes et al. 2015; Morgan et al. 2018). School-based interventions possess an additional advantage over other settings as the programme of delivery can be easily institutionalised (Stone et al. 1998) and children spend a large proportion of their waking hours within the school environment (Gråstén et al. 2017). Physical education lessons and break-times provide the majority of opportunities for physical activity during school hours (Fairclough and Stratton 2005). However, structured PE lessons account for only a small proportion of a child's recommended daily MVPA (van Veurden et al. 2003) and have been found to provide insufficient levels of MVPA (Fairclough and Stratton 2005; Tudor-Locke et al. 2006). Delivery of the primary PE curriculum is challenging due to many factors; including more emphasis on core subjects (Griggs 2010), ineffective teacher training (Harris, Cale and Musson 2012; Morgan et al. 2018) and low levels of confidence in primary school teachers allocated for PE delivery (Morgan and Bourke 2008; Griggs 2010). However, the target of primary PE is not to simply get children active. PE should develop children's movement skills, which might not always result in the child being vigorously active at that point in time, but might lead to improvement in movement skill competence and increase engagement in physical activity during other periods of time (Stodden et al. 2008).

Alongside the considerable amount of break-time available within one school year (three times a day, five days a week = 600 hours a year) (Stratton 1999), a primary school playground with a combination of playground markings and physical structures has the most potential to increase children's physical activity levels (Escalante et al. 2014). However, it has recently been suggested that many health promotions and primary school interventions fail to consider the influence of class cultures and previous dispositions towards physical activity on interventions success (Wiltshire et al. 2017). Also, evidence to suggest which areas of the playground (sports pitches, climbing frames, creative play spaces) are 'most successful' in engaging children in MVPA is lacking. Furthermore, modifiable contextual characteristics of the playground (such as organisation and supervision) have previously been associated with physical activity levels, having both negative (McKenzie et al. 2010) and positive effects (McKenzie et al. 1991). A priority for playground supervisors is keeping children safe, which has previously been found to suppress physical activity levels of children during break-times (McKenzie et al. 2010).

Therefore, the aim of this study was to identify the areas of the playground that had the highest proportion of MVPA episodes during break-times and explore the contextual and environmental characteristics present in these areas which might have promoted MVPA. In addition, we explored the effect that playground supervision and the delivery of organised activities had on the number of MVPA episodes (counts) during break-time.

4.2 Methods

4.2.1 Participants

The primary school for this case study had 528, 5 to 11 year old children enrolled (50.8% male) and was located in a neighbourhood in the lowest 10% on the Index of Multiple Deprivation (English indices of deprivation: Department for Communities and Local

Government: 2010) with 44% of children eligible for free school meals and 70% of children having English as an additional language. All work involved in this project was in accordance with the Declaration of Helsinki. The study received ethics approval from the School of Social Sciences, Humanities and Law, research ethics committee at Teesside University (Application number: **SSSBLREC055:** Appendix E). Following Head Teacher and parental informed consent ('opt out') and child assent, primary school children were observed in the playground environment during break-times on three separate occasions over an eight week period during July and September 2017 (separated by the summer holidays).

4.2.2 Observation method

The System for Observing Play and Leisure Activity in Youth (SOPLAY) (McKenzie 2012) was utilised for observing the children's physical activity levels. The SOPLAY is based on momentary time sampling techniques in which systematic and periodic scans of individuals and contextual factors within pre-determined target areas are made (McKenzie 2016).

Six observers were trained in the mapping protocols for SOPLAY and were familiarised to the school playground and the target areas (Table 4.1). Researchers (MG and AI) engaged with the school staff (teachers and playground supervisors) to ensure the target areas did not cross any boundaries or restrictions enforced by the school. Twelve target areas were originally identified (Table 4.1) and the boundaries made clear to each observer (Figure 4.1).

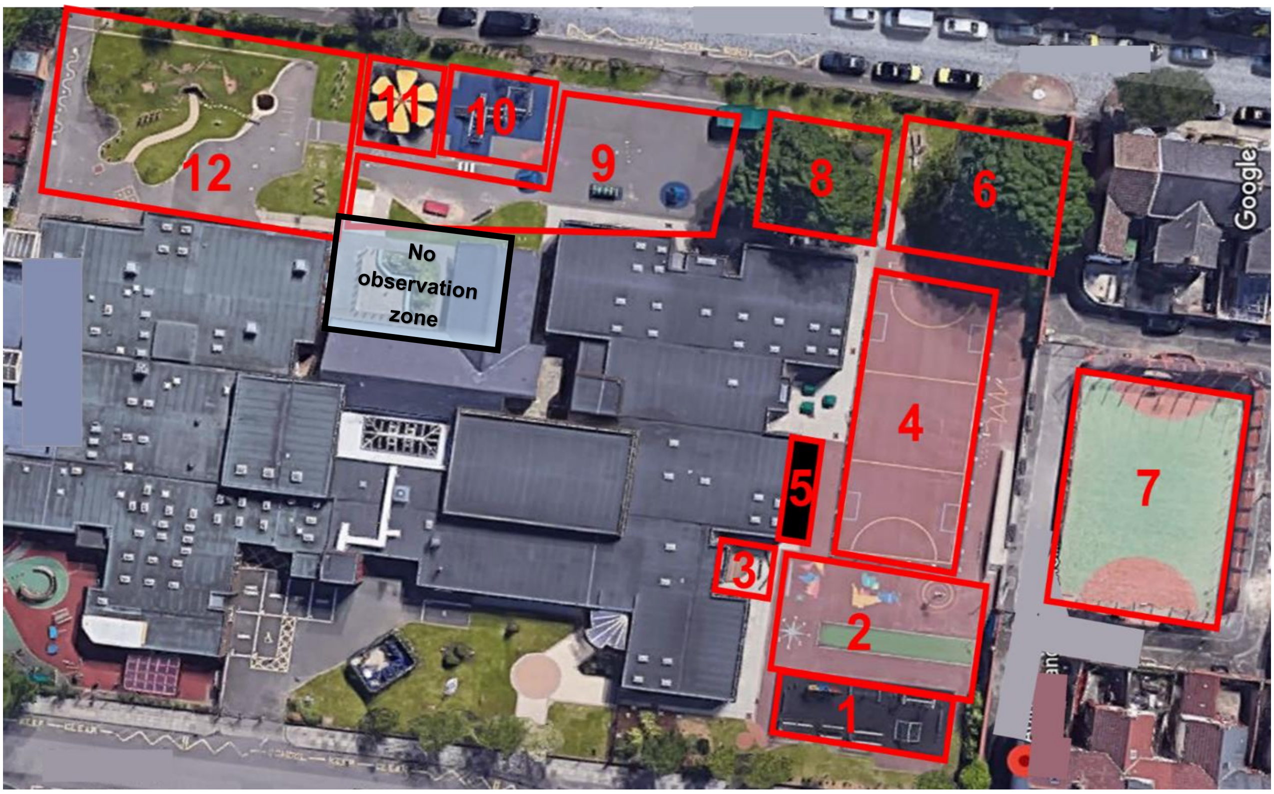


Figure 4.1 – Playground map and boundaries

Three pairs of observers used three separate cameras to record the target areas during break-times. Camera operators took video recordings of each target area in sequence (target area 1 through 12) for 30 seconds at a time throughout morning break (15 minutes) and lunch times (45 minutes) on each day of data collection. Each camera started recording at the same time but at a different scan area (camera one started at area 1, camera two started at area 5, and camera three at area 10) and worked sequentially, ending once break-time was over. This resulted in 611 video clips totalling 306 minutes of recordings between the three cameras. This was an average of 34 minutes per camera, per day (over three days). Time was lost moving between playground areas and at the end of break-times when children were called to line up prior to going back into class. Furthermore, the lunchtime period was inclusive of children eating their lunch so time on the playground was less than the 45 minutes scheduled.

Three trained observers then scored the clips retrospectively, and independently. The use of video recordings has a high degree of agreement with live assessments (Boonzaaijer, van

Dam, van Haastert, 2017) and resulted in a larger number of observations for each target area than would have been possible by using live observations. Target area 5 was subsequently excluded as there were no children observed in this area during any of the video recordings.

When scoring video clips, observers were asked to score the number of episodes of sedentary (SED), light physical activity (LPA) and moderate to vigorous physical activity (MVPA). There was significant potential for the same children to be observed in numerous clips and in a number of different target areas. However, the purpose of the observations was to get an idea of how active each playground area and the playground as a whole was during break-time, and not to track the activity levels of individual children during break-time.

Table 4.1 Defining characteristics of playground areas

Target area	Key area characteristics
1 (KS2)	Large play/climbing frame - climbing Ropes, climbing and scramble nets, balance beams, tyre swings, climbing wall built on a cushioned surface
2 (KS2)	Large open play area – Tarmac surface, playground markings, basket for netball/basketball, walled area (used predominantly with tennis and football)
3 (KS2)	Stage area – a small stage constructed from wood (3mx2m), viewing benches/beams (sometimes used to climb/balance), surrounded by paved surface
4 (KS2)	Multi-sport court – Tarmac surface ball court with markings, goals available on occasion (x2) and balls provided on request. This court is timetabled to make it available to all year groups
5 (KS2) (excluded)	Seating area with small climbing wall – climbing wall on the school building next to a bench provided for children wanting to speak with staff. This area is used more as access to other areas of the playground
6 (KS2)	Tyre climbing area – Multiple rubber truck/tracker tyres fixed to the ground in a different positions surrounded by grass surface – designed to encourage balance
7 (KS2)	Astro turf –5 a-side court providing all weather court for children to play football. Fenced off area with permanent goals and markings
8 (shared)	Seating area – A small area between more active areas with toad stools and a wooden throne built on a cushioned surface
9 (KS1)	Free play – Tarmac surface with markings, wooden tepee's, wooden tunnel, sand box, wooden bench and a sandpit – this area is provided with scooters, tricycles, toy prams etc.
10 (KS1)	Small play/climbing frame – similar to area one but built for younger year groups
11 (KS1)	Sheltered seating area – a hexagonal seating area with 6 benches covered with an aluminium roof (in the shape of a flower).
12 (KS1)	Large open play area – mix of tarmac and grass surface, playground markings, tunnel under a grass mound, wooden posts to encourage balancing, small kitchen area (for role play) and wooden benches.

Definitions for SED (i.e., lying down, sitting or stationary standing; <1.5 MET's), LPA (i.e., walking or activity resulting in similar energy expenditure; >1.5 MET's and <3 METs) and MVPA (i.e., jogging, running, gymnastic/strength exercises or activity resulting in similar energy expenditure; >3 MET's) were defined (Butte et al. 2018; Crane et al. 2018) and agreed prior to observations in order to minimise disagreements (Hawkins and Dobes 1977). Observations began by first scanning the area and recording the number of female children who were observed as either sedentary, light or moderate to vigorously active. The clip was then re-started and the scan repeated immediately for males. Observations started at the left most boundary and were completed left to right at a rate of one child per second according to the guidelines of McKenzie et al. (2016). Each child was observed once during each scan (even if they moved back into view) and backtracking to count new children entering the scan area was discouraged. This was made easier by adding a small observation window to the video clips during video editing. The window moved across the playground area on the video clip at the required speed to help maintain the correct scan tempo.

Any child within a specified target area during a scan was identified as actively participating and scored accordingly. The video clips for each target area were watched in full and a score noted for females followed by males for each clip before moving to the next clip. If children's activity levels were unclear on first observation then recordings were watched back to resolve any uncertainties in activity codes (McKenna and Zwolinsky 2015). Once all clips for the target area were completed the observers moved onto the next set of clips for a different target area. The order that each observer viewed the clips were counterbalanced so that the order of observations did not have an effect on the scoring.

Children were informed about general details of the project and the presence of the observers prior to any data collection. Research staff visited the school on three occasions prior to recording the school playground and were present from the start of the school day until the end of the lunch break-time. These initial visits served the joint purpose of research staff becoming familiar with the playground and the identified target areas, and for children to become familiar with the research staff and cameras. Cameras were not active during these initial visits and data collection began on the fourth visit to the school.

Children were told to take part in the usual playground activities and ignore the presence of the research staff in order to reduce the reactivity of the children. Research staff were asked to inform the children *'we are busy at the minute but I can talk to you later'* as recommended by (Darst, Zakrajsek and Mancini 1989) to further avoid reactive behaviour. To reduce the reactivity to the video camera, any recordings taken in the period before school started (i.e., before 9am, when children who arrived early used the time to access the school playground) were considered 'habituation' and not used in the scoring of playground activity levels (Darst et al 1989). All children had access to the play space that was observed by researchers at some point during the school day. In any instance where the camera affected the behaviour of the children (e.g., children "acting up" for the camera), the decision was made to delete this observation from the recordings. A designated 'no observation zone' was made available for any child that did not wish to take part in the study (Figure 4.1).

4.2.3 SOPLAY Training

Prior to live observations, six observers used practice and gold standard assessment videos (using available resources from www.activelivingresearch.org) and recorded observer agreement and relative reliability. Inter-observer agreement (IOA) was calculated to establish the agreements between observers and the gold standard score. An IOA equal to or above 0.8 (or 80%) has previously been used as an acceptable threshold for acceptable observer agreement (McKenzie 2012). Furthermore, the Inter-class correlation coefficient (ICC) for agreement (ICC(A, 1)) was calculated in accordance with McGraw and Wong (1996) to establish criterion-referenced reliability (McGraw and Wong 1996).

Inter-rater reliability (IRR) was calculated using Cohen's kappa (k) with qualitative inference based on the following; 0.81-1.00, almost perfect; 0.61-0.80, substantial; 0.41-0.60, moderate; 0.21-0.40, fair; 0.00-0.20, slight; <0.00, poor (Landis and Koch 1977). Practice videos were scored independently then discussed as a team. Once observers met the criteria for acceptable reliability (IOA>80% and ICC>0.75) for the training and gold standard assessment videos they moved to the next stage of testing (see Figure 4.2 for the stages of training and calibration procedures for observers). As a result of the reliability and agreement scores for the practice videos, one observer was removed from further assessment due to been unable to reach the acceptable level of IRR and IOA. A further two out of the six observers were placed on a backup list and asked to continue with training videos once per month (until the end of live observations) in case they were needed in future observations (Figure 4.2).

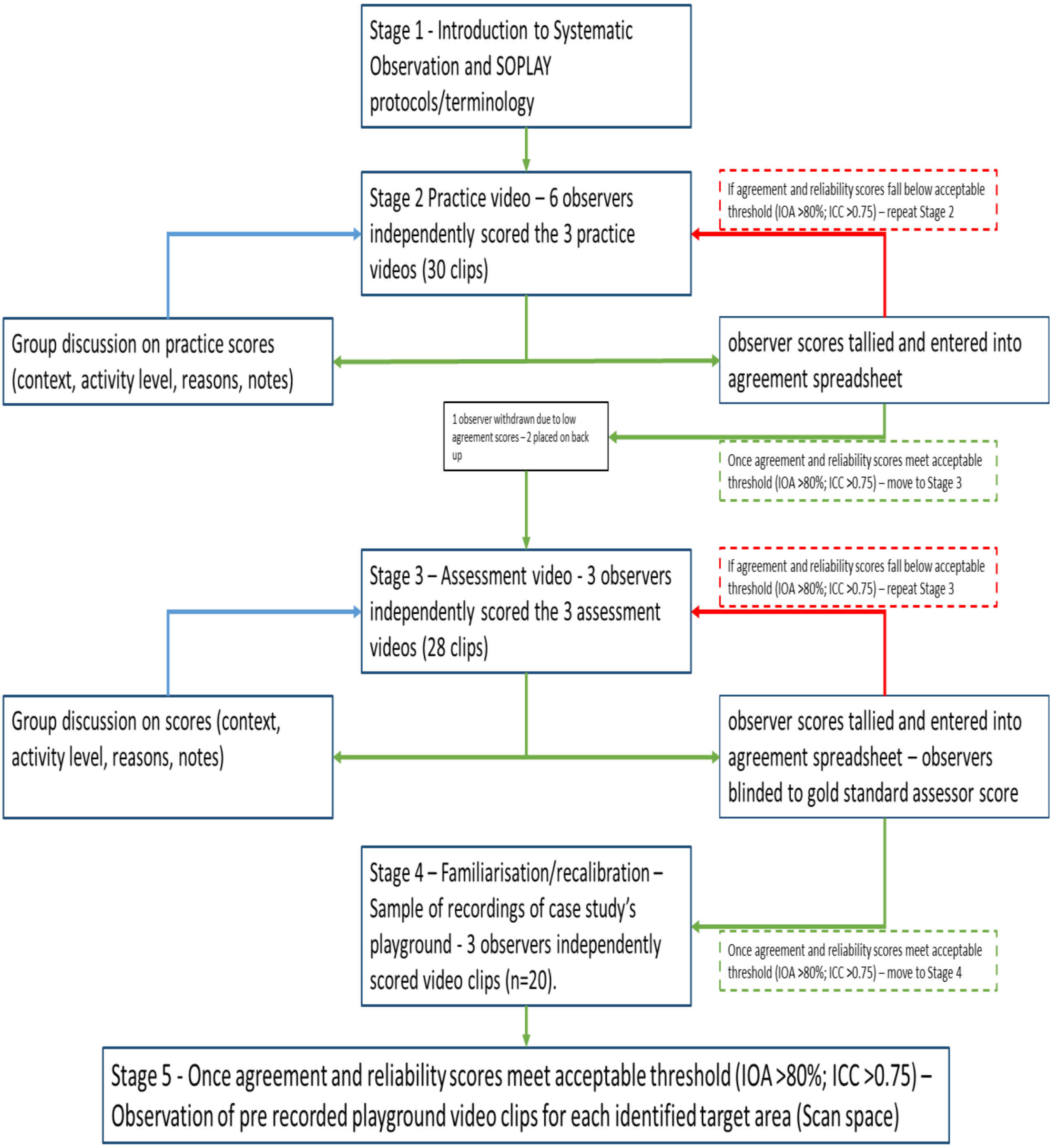


Figure 4.2 stages of SOPLAY training

The ICC for the practice videos were classed as 'high' to 'extremely high' (0.89-1.00) based on the following thresholds: >0.99, extremely high; 0.99–0.90, very high; 0.75–0.90, high; 0.50–0.75, moderate; 0.20–0.50, low; <0.20, very low (Malcata, Vandenbogaerde and Hopkins 2014). The ICC, IRR and IOA for the assessment videos are presented in Table 4.2. The change in IOA and IRR from initial assessment to post training can be seen in Figure 4.3. Reliability of observers scored against the lead observer (MG) can be seen in Appendix F.

Table 4.2 Reliability of observers against a gold standard criterion score for assessment videos.

Gold assessment	Sedentary			LPA			MVPA		
Observer ID	ICC; (95%CI)	IOA %	IRR k	ICC; (95%CI)	IOA %	IRR k	ICC; (95%CI)	IOA %	IRR k
MG	0.97; (0.93-0.98)	89	0.77	0.99; (0.97-1.00)	96	0.92	1.00; (1.00)	100	1.00
AI	0.95; (0.87-0.97)	86	0.69	0.93; (0.84-0.96)	79	0.60	0.95; (0.87-0.97)	82	0.75
MW	0.96; (0.91-0.98)	86	0.70	0.96; (0.92-0.98)	79	0.51	0.98; (0.96-0.99)	93	0.83

Abbreviations: CI = Confidence Intervals; ICC = Inter-class correlation coefficient; IOA = Inter observer agreement; IRR = Inter-rater reliability; LPA = light physical activity; k = Cohen's Kappa; MVPA = moderate to vigorous physical activity

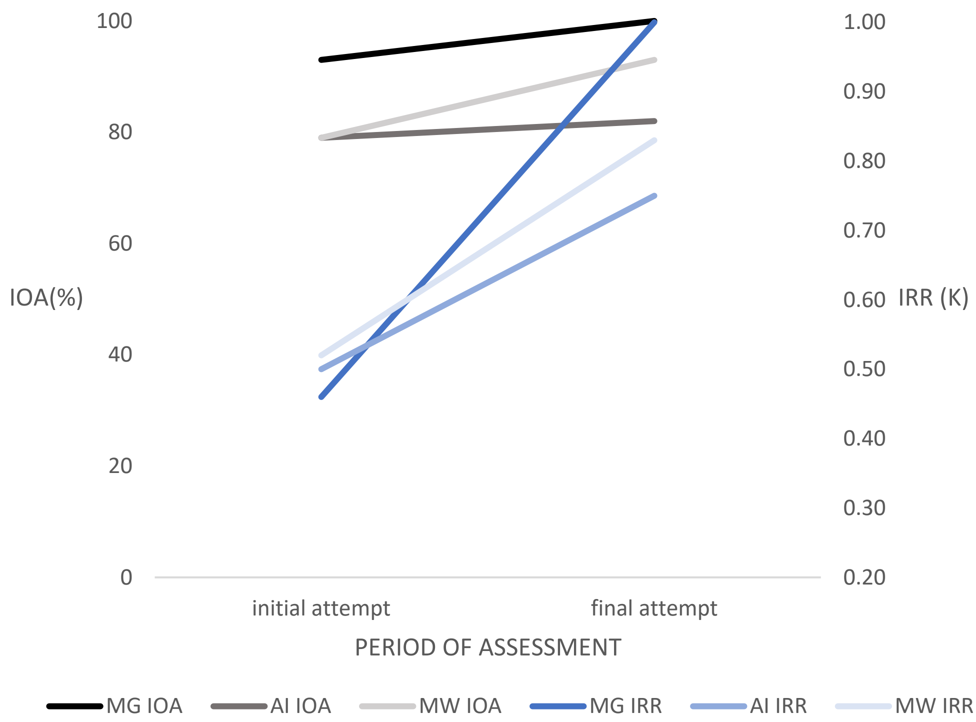


Figure 4.3. The change in Inter-observer agreement (IOA) and Inter-rater reliability (IRR) for the three observers from pre to post training

4.2.4 Data Analysis

- Activity levels

Video clips from the three days were pooled and grouped by target area. The percentage of SED, LPA and MVPA was calculated for each 30 second clip by dividing the number of episodes for each activity code by the total number of observations. Proportions (mean ± SD) of SED, LPA and MVPA episodes were then calculated for each target area and for the playground as a whole. Target area proportions for each activity were calculated for male and female children separately; and males and females combined, in order to establish hotspots for MVPA. Heat mapping software (http://heatmapper.ca; GenomeAlberta and Wishart research group, Canadian Institute of Health Research (CIHR), Alberta, Canada) was used to develop a heat map of individual target area counts for MVPA. A distribution map was generated using each of the eleven target areas by using the number of episodes of MVPA observed in each area. Markers with a larger Gaussian radius and a larger contrast between blue ('cold') and red ('hot') represent a target area as a 'hotspot' for MVPA.

- Contextual factors

The five contextual factors in the SOPLAY were scored as counts (number of times the contextual variables were present) during each observation and summed for each target area. A score of *'1'* was given to any instance that a contextual factor was present and *'0'* in any instance it was absent. These scores were used to calculate the number of times the contextual variables *'accessible', 'usable', 'supervised', 'organised'* and/or *'equipped'* were present in the playground. 'Accessible' and 'usable' were scored if children had access to the area in the observation and that area was in a usable condition (i.e., not broken, damaged or flooded etc.). 'Supervised' was scored whenever there was an adult in the observation area whose role was primarily behaviour management and child safety. 'Organised' was scored if there was adult supervision in a role beyond that of the break-time supervisors which involved instruction and facilitation of an organised activity. Finally, 'equipped' was scored if there was movable equipment (scooters, skipping ropes, hula hoops etc.) provided beyond what would normally be expected in that area. Areas with fixed playground equipment (climbing frames, goals, sandpits) were not scored as 'equipped' as these structures were used in the mapping of the playground zones and would have misleadingly amplified the effect of the contextual variable 'equipped' on physical activity levels.

4.2.5 Statistical analysis

Raw data was processed in Microsoft Excel (Microsoft Office 2016) spreadsheets to produce counts (number of MVPA episodes) and the proportions of SED, LPA and MVPA episodes (males, females and combined) for each target area. Data are presented as mean ± SD.

Negative binomial regression was used to determine the extent to which the presence or absence of each contextual factor relates to the MVPA counts and total activity counts (TA = LPA + MVPA) during break-time. The variables “Accessible” and “Usable” were present in 100% of the observations so were excluded from the analysis. Data are presented as incidence rate ratios (RR) with 95% confidence intervals (CI). The RR represents the ratio of counts of MVPA episodes for the presence versus absence of the contextual variable.

4.3 Results

To explore a gender preference for area, irrespective of activity level we calculated the average number of male and female children present in each target area during the 30 second video clips (Table 4.3).

4.3.1 Activity levels

The proportion of MVPA episodes for the playground as a whole during break-time (male and female children combined) was 34% ± 26% (Table 4.4). When the total number of episodes (sum of SED, LPA and MVPA for males and females combined) for each target area was the denominator, target areas 4 and 7 (KS2) had a higher proportion of MVPA episodes for males (30% ± 23% and 35% ± 26%) compared to females (5% ± 10% and 4% ± 8%) and target areas 1 and 6 (KS2) had a higher proportion of MVPA episodes for females (36% ± 18% and 31% ± 27%) compared to males (20% ± 18% and 16% ± 19%) (Table 4.4). MVPA episodes in KS1 target areas (9 to 12) had a consistently higher contribution from males observed in MVPA, compared to females (Table 4.4).

Table 4.3. Mean number of female and male children that were present in each target area (data from the 3 days combined)

Target area	Males (mean ± SD)	Females (mean ± SD)	Mean diff	95% CI Lower	95% CI Upper
1	4.2 ± 2.6	11.7 ± 8.8	7.53	5.22	9.84
2	6.9 ± 5.3	4.5 ± 6.3	-2.45	-5.45	0.55
3	2.1 ± 1.9	2.8 ± 2.4	0.80	-1.20	2.80
4	10.7 ± 4.9	2.9 ± 4.8	-7.73	-9.13	-6.33
6	3.2 ± 3.5	5.1 ± 3.9	1.96	0.40	3.53
7	9.9 ± 4.7	1.4 ± 1.5	-8.50	-9.91	-7.09
8	4.6 ± 3.9	6.2 ± 3.0	1.56	-0.54	3.66
9	6.9 ± 5.2	5.7 ± 4.7	-1.27	-2.36	-0.18
10	7.6 ± 3.2	5.5 ± 3.1	-2.17	-3.43	-0.91
11	3.4 ± 2.4	5.3 ± 2.9	1.93	0.30	3.26
12	9.5 ± 6.6	7.1 ± 4.9	-2.34	-3.56	-1.11
Areas that promote team sport (4 & 7)	9.9 ± 4.8	2.0 ± 3.5			
Areas that promote social interaction (1, 6 and 11)	3.5 ± 2.9	7.9 ± 7.2			

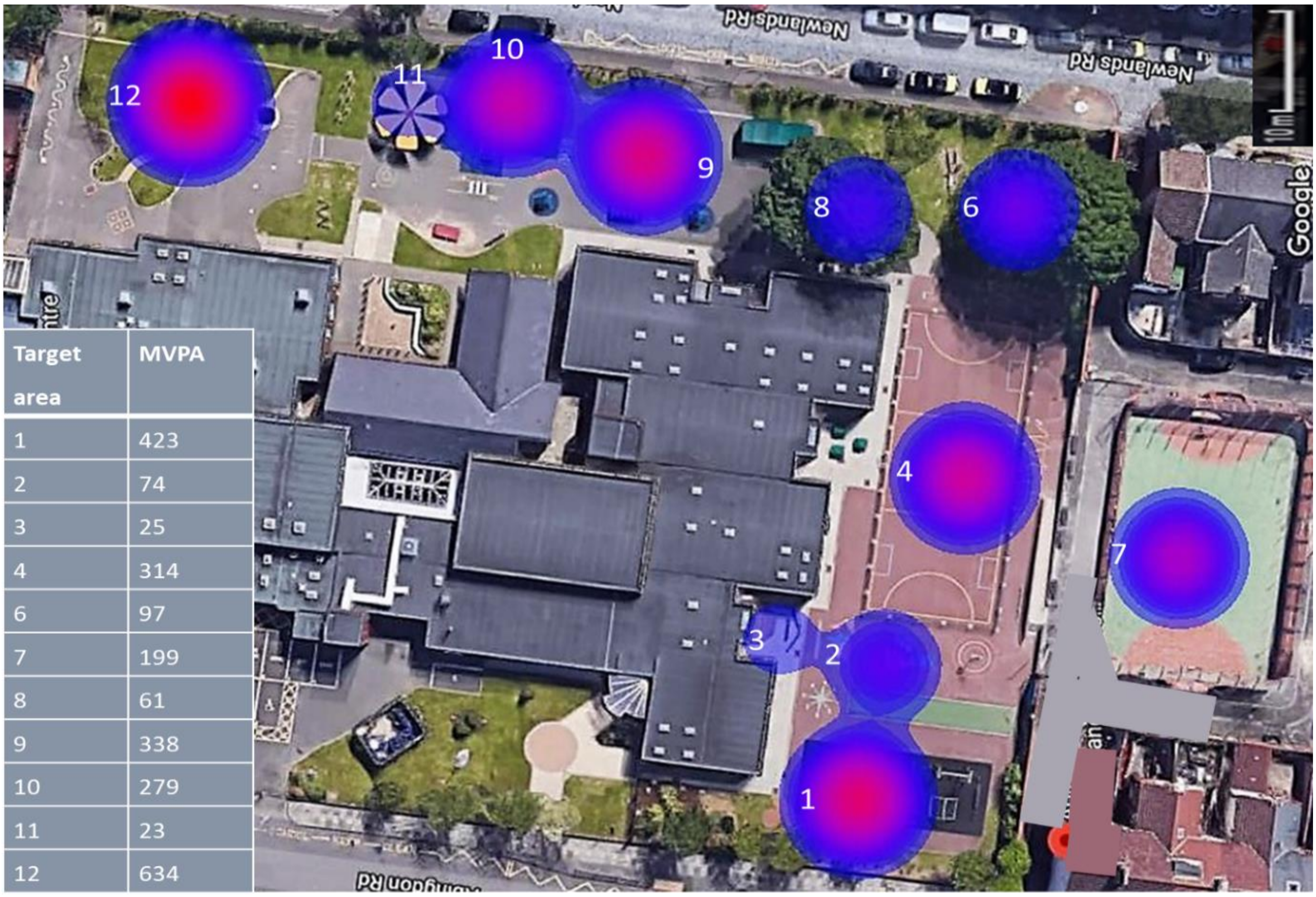
Table 4.5, displays the proportions of SED, LPA and MVPA episodes for males and females when using target area totals (sum of SED, LPA and MVPA) for male and female children separately as the denominator. When looking at the playground as a whole, 38% ± 30% (mean ± SD) of the total number of episodes recorded for male children were MVPA. The proportion of episodes for females on the playground that met the MVPA threshold was 31% ± 32%. Table 4.5, highlights that in most cases there are similarities in the areas that promote a higher amount of MVPA for the KS2 areas for both male and female children (target area 1 to 7) present in each area. However, there are differences in the areas which promote higher proportions of MVPA episodes for males and females at KS1 (target areas 9 to 12). The proportion of MVPA episodes for males observed in KS1 target areas 9, 10, 11 and 12 were 31 ± 29%, 50 ± 25%, 14 ± 26% and 41 ± 26%, respectively (Table 4.5). The percentage of

MVPA episodes for females observed in KS1 areas were lower for every area (9 = 21 ± 27%, 10 = 37 ± 25%, 11 = 7 ± 13% and 12 = 29 ± 28%).

The MVPA total counts (male and female combined) for each target area can be seen in Fig. 4.4. Target area 1 and 12 can be considered MVPA hotspots due to a higher count of MVPA episodes in these areas. Areas containing climbing and play apparatus (area 1, 10 & 12) and multi-use courts/pitches (area 4 & 7) had a higher count of MVPA episodes, compared to areas with creative play equipment (area 3, 6 & 8).

4.3.2 Contextual factors

Negative binomial regression was applied for MVPA counts and TA counts based on the contextual variables supervised, organised, and equipped. In areas where the contextual variable ‘organised’ was present, the count of episodes of physical activity was 2.70 (95%CI: 1.87 to 3.91) and 1.79 (1.23 to 2.60) times that observed when ‘not organised’, for MVPA and TA, respectively. The contextual variable ‘supervised’ was associated with 1.34 (1.18 to 1.53) and 1.40 (1.24 to 1.58) times the counts for MVPA and TA, respectively, compared to areas that were not ‘supervised’. For areas with the equipment provided (‘equipped’), without the contextual variables ‘organised’ or ‘supervised’, the number of episodes was 0.85 (0.75 to 0.96) and 0.99 (0.89 to 1.12) times that observed in areas without provided equipment for MVPA and TA, respectively.



Target area	MVPA
1	423
2	74
3	25
4	314
6	97
7	199
8	61
9	338
10	279
11	23
12	634

Figure 4.4 Moderate to vigorous physical activity (MVPA) heat map for individual target area

Table 4.4. Target area activity levels – Proportion (%) of observed episodes for each activity threshold contributing to the total number of episodes (males and females combined for target area totals) (Mean; SD)

	Mean (SD)											
	Key stage 2						Shared	Key stage 1				
Target area	1	2	3	4	6	7	8	9	10	11	12	Playground
Female SED	12 (15)	4 (9)	22 (29)	3 (7)	12 (13)	1 (3)	30 (22)	12 (15)	7 (10)	41 (25)	17 (21)	13 (19)
Female LPA	20 (18)	18 (25)	19 (26)	7 (15)	19 (19)	5 (8)	16 (15)	23 (21)	20 (17)	20 (22)	15 (12)	17 (19)
Female MVPA	36 (18)	15 (26)	12 (23)	5 (10)	31 (27)	4 (8)	14 (20)	11 (17)	15 (12)	6 (11)	14 (18)	14 (19)
Male SED	6 (11)	12 (23)	19 (29)	18 (24)	6 (10)	8 (12)	20 (19)	13 (15)	8 (10)	21 (23)	15 (15)	13 (18)
Male LPA	6 (9)	37 (32)	15 (18)	38 (25)	15 (22)	46 (21)	10 (13)	25 (21)	21 (16)	7 (11)	17 (14)	22 (22)
Male MVPA	20 (18)	14 (18)	13 (26)	30 (23)	16 (19)	35 (26)	10 (12)	16 (18)	29 (19)	5 (11)	21 (17)	21 (20)
% MVPA episodes during break-time	56 (23)	29 (28)	24 (30)	35 (27)	47 (30)	39 (26)	24 (23)	27 (23)	45 (21)	11 (14)	35 (22)	34 (26)
% LPA episodes during break-time	26 (20)	55 (30)	24 (28)	44 (25)	35 (26)	51 (23)	26 (19)	48 (25)	41 (22)	27 (23)	33 (18)	39 (25)
% SED episodes during break-time	18 (19)	16 (25)	42 (36)	21 (24)	18 (17)	9 (12)	51 (28)	25 (24)	15 (14)	62 (23)	32 (22)	26 (26)

Abbreviations: SD = standard deviation; LPA = light physical activity; MVPA = Moderate to vigorous physical activity; SED = sedentary activity

Table 4.5. Target area activity levels – Proportion (%) of observed episodes for each activity thresholds by Gender (totals for males and females separated)

	Mean (SD)											
	Key stage 2						Shared	Key stage 1				
Target area	1	2	3	4	6	7	8	9	10	11	12	Playground
Female SED	17 (21)	13 (27)	39 (40)	23 (34)	23 (28)	11 (26)	51 (27)	28 (31)	16 (20)	62 (29)	33 (30)	28 (31)
Female LPA	28 (27)	49 (36)	43 (39)	45 (41)	32 (31)	51 (44)	28 (25)	50 (34)	47 (28)	30 (26)	38 (27)	41 (33)
Female MVPA	55 (29)	38 (39)	18 (26)	33 (35)	45 (34)	39 (44)	21 (27)	21 (27)	37 (25)	7 (13)	29 (28)	31 (32)
Male SED	20 (27)	18 (26)	40 (39)	19 (25)	17 (30)	9 (12)	48 (37)	24 (26)	13 (15)	62 (35)	27 (24)	24 (28)
Male LPA	23 (25)	59 (33)	39 (34)	43 (26)	33 (36)	52 (23)	26 (31)	46 (30)	27 (26)	24 (33)	31 (20)	38 (29)
Male MVPA	57 (33)	24 (28)	22 (32)	37 (28)	50 (40)	39 (26)	26 (31)	31 (29)	50 (25)	14 (26)	41 (26)	38 (30)

Abbreviations: SD = standard deviation; LPA = light physical activity; MVPA = Moderate to vigorous physical activity; SED = sedentary activity.

4.4 Discussion

The aim of this study was to identify the areas of the playground that male and female children chose to visit at break-times and the contextual variables present in these areas. In addition, we observed the engagement in MVPA of children in these areas and identified key characteristics that may promote physical activity during break-times. A key finding was that the environmental characteristics of playground zones and the activities they promote (e.g., team sport, socialisation, and adventure play) had an effect on the activity levels and behaviours of children during break-time. By observing the children's physical activity behaviours in these target areas, we were able to map MVPA 'hotspots' on the primary school playground. Further we were able to identify that the 'organisation', 'supervision' and 'equipment' provision during break-time had positive or negative consequences on the behaviours of children during break-time.

A previous systematic review affirmed that primary school playgrounds which offer a variety of strategies aimed at increasing physical activity levels are the most effective (Escalante et al. 2014). The primary school playground observed in this study matches the description of "variety" (i.e., playground markings, physical structures and games equipment) implied in Escalante et al. (2014) and had an extensive range of activities and play spaces which were accessible and usable during all observations. Findings from the current study support Escalante's conclusions, with 73% of all children observed during break-times showing engagement in some form of physical activity (LPA+MVPA). However, only one third of the activity episodes were of children observed in MVPA in the playground. Further, there was a trend for slightly higher proportion of MVPA episodes for males (38% ± 30%) than for females (31% ± 32%). These findings support the previous work of Anthamatten, Brink, Kingston et al. (2014) who conducted similar observations exploring the patterns in children's physical activity behaviours within different playground spaces. Despite potential issues with pseudo-replication in their analysis methods, the authors identified that there was a significant mean percentage difference (6.73%: 95%CI; 3.5 to 9.9; p value: 0.001) between the percentage of male (39.6%) and female children (32.9%) engaged in MVPA activity in the playground.

There was a higher proportion of MVPA episodes for KS2 males compared to females in area's which promoted team sports (areas 4 and 7) and a higher proportion of MVPA episodes for KS2 females in area's that promoted climbing and social interaction (areas 1 and 6). These gender dissimilarities may in part be explained by a tendency for females to play in areas not dominated by sport and which promote social interaction (Renold 1997; Lucas and Dyment 2010) whilst males tend to dominate areas within school playgrounds that are designed for competitive sports (Lucas and Dyment 2010). Previous observations have shown similar differences in utilisation of target area's by gender (Colabianchi, Maslow, Swayampakala 2011; Anthamatten et al. 2014) with females more likely to use areas with a wide variety of play features (Colabianchi et al. 2011) and manufactured equipment (Lucas and Dyment 2010) and less likely to use areas that have sports equipment provided (Anthamatten et al. 2014). Similarly, in this thesis, gender differences were evident in the KS1 playground with higher numbers of KS1 males than females observed in active play areas and a higher number of KS1 females than males observed in the more inactive, social areas of the playground.

Conversely, there were KS2 females and males observed in this study in playground behaviours that refute the traditional gender stereotypes highlighted previously (Renold 1997; Lucas and Dyment 2010). For example, there were a number of female children in this playground that chose to access areas that were more popular with male children (areas 4 and 7; team sports) and although fewer in number, they were as active as the males observed in the same areas (area 4: female = 33%; male = 37%; area 7: female = 39%; male = 39%). This was a similar picture when observing the KS2 areas that were more favourable with KS2 females (area 1: female 55%; male 57%; and area 6: female 50%; male 45%). This suggests that something other than playground preferences is responsible for the difference in target area utilisation between male and female children. Research surrounding the association between FMS and physical activity levels might help to explain the differences in children's activity choices. Being male has previously been reported to be a positive correlate for object control skills (Barnett et al. 2016b) whilst locomotor skill competencies are more strongly associated with females (Iivonen and Sääkslahti 2013). Furthermore, it is likely that the type of activities children take part in are a result of similarities in movement ability and movement skill competency, with children of low physical competence reluctant to approach activities requiring a higher level of ability (Barbour 1999) irrespective of differences in gender.

Schools with manufactured equipment and installed play equipment; such as climbing frames and goals, have previously been found to promote the highest levels of MVPA (Farley, Meriwether, Baker et al. 2008; Dyment, Bell, Lucas 2009). Findings which are supported by this study, with areas that had some form of fixed exploratory play equipment (climbing and balancing), resulting in counts for MVPA much higher than areas without, irrespective of the area size. For example, target area 4 has a much larger footprint than area 1 (Fig. 4.4); therefore, its capacity to take a much larger number of children before becoming saturated indicates greater potential opportunities for children to be active. However, target area 1 has a higher number of MVPA observations despite being much smaller in size.

An important question to consider in the relationship between playground areas and children's activity levels is how environmental variables act on children's decision making when selecting areas of the playground to "play" in. Baines and Blatchford (2019b) identified from self-report questionnaires that over the past twenty-two years there has been a marked increase in adults supervising at break-times. Although this is likely to be very different at each school (due to resources and funding) it is important to understand how this supervision and/or organisation of activities by a teacher, coach or lunchtime supervisor increase or decrease the likelihood that a child will take part in MVPA. The findings from this study would suggest that areas of the playground that have organised activities (definitive structure with instruction and purpose) are likely to result in an almost three fold (RR = 2.7) increase in the rate of MVPA episodes compared to areas with less structure. It has been suggested that the activity levels of primary school children benefit from the structured break-times by getting help in planning and developing games (Ramstetter, Murray, Garner 2010). In addition to some informal instruction and encouragement, organised activities are often supervised by an adult, providing a safe space, free from aggressive and dominating behaviours (Ramstetter et al. 2010) where a child may be more inclined to make an attempt to take part in something they usually avoid for fear of unwanted negative attention. In this study, areas that had supervision but without formal instruction resulted in a more episodes of MVPA (RR 1.34) compared to areas with no supervision. In support of these findings, Dyment et al. (2009) established that areas without structure, organisation or equipment had the lowest rates of MVPA on the playground. In contrast, McKenzie et al. (2010) observed that in supervised areas, the odds of children engaging in MVPA were half as likely as unsupervised areas. Further, areas that were organised, had lower odds of children engaging in MVPA compared to less structured areas (McKenzie et al. 2010).

The behaviours and actions of supervisors can result in different physical activity levels of children (Hyndman and Telford 2015; Caro, Altenburg, Dedding, Chinapaw (2016). In the current study, areas that were observed as 'organised' were almost always 'supervised'. Study differences in MVPA levels observed may be the result of the activities that were organised and/or the actions and behaviours of the supervisor (Caro et al. 2016) and not simply the presence of each contextual variable in isolation.

Previous studies have also found positive associations between the provision of playground equipment and higher rates of MVPA (McKenzie et al. 2010; Haug, Torsheim, Sallis, Samdal 2010; Nielsen, Taylor, Williams, Mann 2010). Conversely, target areas with additional equipment provided in this study resulted in a lower number of MVPA episodes observed. The school in this study supplied children with scooters, tricycles and prams/pushchairs. The use of scooters and tricycles could quite easily have been scored as a sedentary activity during the window of observation. Moreover, the equipment was predominantly provided to the KS1 area, therefore it might be possible that the equipment provided required more advanced movement skills (e.g., balancing on a scooter) and as a consequence resulted in a higher percentage of children observed in sedentary activities in these areas (target areas 8, 9 & 12; Table 4.4). Further research is needed to address the impact that the 'management' of the playground environment (organisation and supervision) has on physical activity during playtime (Ridgers et al. 2006; Ridgers, Salmon, Parrish et al. 2012).

4.4.1 Strengths, limitations and future directions

This study set out to explore the different contexts in which children play and the relationship to physical activity levels. Though the results of this study might not be generalizable to the primary school population as a whole, similarities do exist between the current study and previous research (Lucas and Dyment 2010; Anthamatten et al. 2014; Barbour 1999). Diversity between the town centre location in this study and more rural residing schools (SES, ethnicity, playground size etc.) might present in a completely different range of activity behaviours (Lucas and Dyment 2009). Children from a lower SES have lower FMS competence (Barnett et al. 2016), lower physical activity levels (Drenowatz, Eisenmann, Pfeiffer et al. 2010) and a higher incidence of obesity (Lioret, Maire, Volatier, Charles 2007) contributing to an increased health risk compared to children with a higher SES.

Wiltshire et al. (2017) suggested that disengagement in certain activities because of differences in social class might already exist in childhood. Any interest or desire to engage with a target area in this study may have been overwhelmed by this predefined set of activities or behaviours perceived as "acceptable", by the predominantly low SES population targeted in this study. Therefore, primary schools comprising of a larger number of children from a higher SES may find their children react differently to a playground environment similar to that of the school observed in this study.

A key strength of this study was the use of validated systematic observation methods to understand the context in which children are active during break-time. To ensure validity and reliability of the recorded physical activity data, systematic observation uses very specific processes and protocols, allowing for a greater depth of understanding of the physical activity behaviours of children. This makes it very labour intensive, leading to an underutilisation of the method. However, many alternative methods (accelerometers and pedometers, self-report) fail to consider the importance of the context in which physical activity occurs (McKenzie and van der Mars 2015). Although systematic observation is not without its limitations as a method for measuring children's physical activity levels (McKenzie and van der Mars 2015), when the correct methods for training and calibration of observers is maintained and monitored, systematic observation is the most effective method of measuring child and youth physical activity behaviours (McKenzie and van der Mars 2015; Saint-Maurice, Welk, Ihmels 2011). Although the use of video cameras has the potential for children to engage in reactive behaviour, the use of video recordings in this study was considered an advantage in ensuring a higher level of accuracy and for the ability to resolve uncertainties in activity codes (Darst et al. 1989).

Observations and regression analysis used in this study allowed for comparisons between contextually diverse target areas. The observational method used in this study allowed us to get a population level measure of children's activity levels during break-times. Therefore, children may have moved between playground areas throughout the break-time periods, contributing to the activity counts in more than one target area. Although the regression model and outcomes are largely unaffected by this, the authors wish to advise readers that for this reason the regression analysis in this study should be considered exploratory and warrants cautious interpretation of the confidence intervals for the model as the counts (episodes) of MVPA are not from independent samples. Furthermore the activity levels reported should be interpreted as the number of activity episodes observed during break-time and not as individual children's physical activity levels. Running statistical analysis as if each observation was from a separate child risks 'simple' pseudo-replication (multiple measures per experimental unit; in this case a child) and 'temporal' pseudo-replication (multiple measures taken successively in time and treated as different experimental units).

Although there were differences noted in the target areas which promoted higher amounts of MVPA, the large standard deviations for each of the activity thresholds (SED, LPA and MVPA) highlights the sporadic nature of children's engagement with physical activity. Future research should consider combining measurement methods (GPS tracking, accelerometers and observation) in order to get a more holistic view of playground physical activity levels during break-times.

Future research should also consider recording the number of male and female children that use particular types of equipment during observations. According to Cherney and Dempsey (2010), children determine (in)appropriate gender related behaviours by responding to their environments very early in life and avoid things they like due to their perceptions of gender appropriateness. The presence of dolls and buggies (stereotypically girls toys), which were provided in this playground, are believed to result in nurturing behaviours (Kollmayer, Schultes, Schober et al. 2018) likely to result in lower levels of physical activity. This study did not track the gender of the children using the equipment provided and therefore is unable to provide clarity on this area. Nevertheless, it is possible that the negative relationship between provision of equipment and MVPA levels in this study is the result of the types of equipment provided. This is an important consideration as the activity levels in the playground may be mediated by the gender biased equipment offered.

4.5 Conclusion and PhD implications

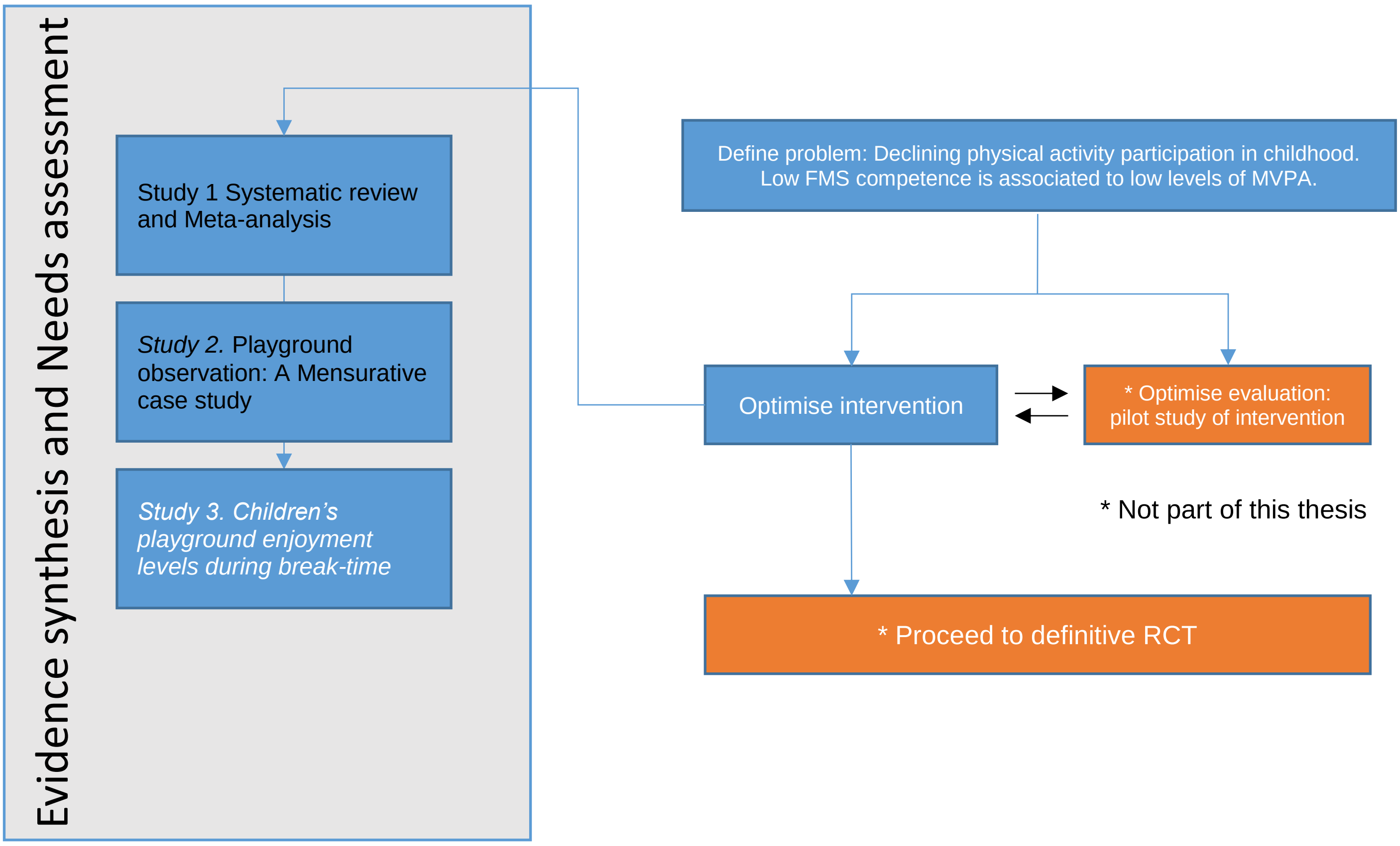
Physical activity levels of children during break-time are influenced by a number of external and internal variables. The differences in playground utilisation between genders is unsurprising, however; the reasons behind these differences are less clear. This study would support claims that movement competency and competency in individual FMS have some association with the choices children make when deciding which areas of the playground to use, however is unable to provide evidence of this relationship. Furthermore, findings from this study suggest the levels and methods of supervision, organisation and equipment might influence the levels of MVPA children engage in at break-times. Exploring some of the defining characteristics of the playground areas which have resulted in a higher number of MVPA counts would aid playground designers in manufacturing play equipment that promotes a higher level of activity over a larger play space, incorporating some of the “colder” activity areas. Furthermore, understanding the areas of the playground which promote the higher levels of MVPA can aid playground supervisors in supporting children to be more active during break-time.

Findings from chapter 3 of this thesis led to the inference that the inclusion of FMS activities to a physical activity intervention would enhance the levels of MVPA that children participate in on a daily basis. The findings from this chapter (chapter 4) highlight areas of the playground that might benefit from such an intervention, increasing the amount of MVPA undertaken in the less utilised areas of the playground. It is crucial, however, that any future playground intervention does not negatively influence the already high levels of MVPA observed in some areas of the playground. Conversely, the improvements in an individual’s FMS competence and associated confidence, is likely to lead to a more extensive range of activities observed in all areas of the playground.

The break-time observations here highlight how children use the playground in its current form. However, the reason for these playground behaviours is unclear. Do children adopt these behaviours because of the constraints on the playground (individual, social, policy) or more simply, because they enjoy using these areas and the activities promoted within?

Future work should explore the enjoyment of current playground activities during break-time. The outcomes would support the findings from the current study and inform the future development of a FMS playground intervention, focussed on activities that children enjoy in areas that best promote high levels of MVPA.

CHAPTER 5: PRIMARY SCHOOL CHILDREN'S ENJOYMENT OF PLAYGROUND ACTIVITIES IN THE TEES VALLEY



Chapter aim: Determine children's break-time enjoyment levels of various playground activities. Explore school staff and child perceptions of break-time enjoyment levels.

Study design: Cross-sectional Likert survey

Key points: Highest enjoyment levels were recorded at social levels (friendship). Subtle differences in enjoyment levels were present between male and female children which supported the activities observed in chapter 4. School staff and pupils self-reported enjoyment scores differed at individual, social and environmental levels of the socio-ecological model. The implications of these findings for future intervention planning are discussed in chapter 7 and 8.

5.1 Introduction

Physical inactivity is prevalent among children of primary school age in the UK (Sport England 2018) and worldwide (Guthold, Cowan, Autenrieth et al. 2010). Physical activity participation is mediated by a number of physical and psychological factors (WHO 2018; Wilkie, Standage, Gillison et al. 2018; Tsuda, Goodway, Famelia and Brian 2019). Recent research exploring the relationship between FMS competence, perceived competence and physical activity participation in children found that 39% of the variance in accelerometer measured MVPA levels could be explained by the participants FMS competence and their perceived physical competence (Tsuda et al. 2019). In this study, the largest contribution to the model was from actual movement competence. However, in some cases, a self-perceived low level of competence in children may be more important than actual ability (Welk 1999).

For example, in relation to Stodden et al. (2008) model of engagement, an individual with a low level of perceived competence, regardless of actual ability, would likely follow a "negative spiral of disengagement", decreasing the likelihood of that child attempting future activities requiring similar skills. On entry to primary school (5 years of age in the UK) children's actual and perceived competency are incongruent, meaning a higher likelihood for children to continue with their physical pursuits, even if the outcome is an unsuccessful one (LeGear et al. 2012). This is important, because as children age, their actual and perceived competencies become more aligned and a low level of perceived competence is more likely to lead to a reluctance to take part in future physical activities.

Furthermore, a low level of perceived competence in physical tasks would lead to low self-efficacy and low levels of enjoyment in environments that promote physically active behaviours. Welks (1999) earlier model suggested that self-efficacy, perceived competence, enjoyment, and access to an appropriate environment are the most common determinants of physical activity. As children between 5 and 11 years of age can spend up to 30 hours per week within the school environment (Dobbins, Husson, DeCorby et al. 2013) it is important to gain a greater understanding of how the aforementioned determinants (enjoyment, self-efficacy and perceived competence) might affect children's physical activity participation during the school day. There are a number of environments and interactions within the school environment that can influence the levels of MVPA and engagement in physical activities (Golden and Earp 2012). Furthermore, the socio-ecological model (SEM) of health and physical activity (Davison and Birch 2001) identifies individual components (individual, social, environmental and policy) that interact and affect the effectiveness of behaviour change interventions.

Physical education (PE) has traditionally received the largest share of the responsibility for school based physical activity promotion (Cordon and De Bourdeaudhuij 2002). However, structured PE classes occur irregularly throughout the week in primary schools and are estimated to contribute to as little as 1% of a child's day (Fox et al. 2004). Conversely, school lunch and break-times occur daily and can contribute to more than 8% of a child's waking hours (Willenberg, Ashbolt, Holland et al. 2010) providing an ideal opportunity for physical activity promotion (Ridgers, Stratton, Fairclough et al. 2007) and social and emotional development (Massey, Nelson and Salas 2019).

There is evidence to suggest that time spent outdoors is positively associated with physical activity levels (Sallis, Prochaska, Taylor 2000; Schaefer, Plotnikoff, Majumdar et al. 2014), cardio-respiratory fitness (Schaefer et al. 2014) and FMS competence (Niemistö, Finn, Haapala et al. 2019). Likewise, MVPA and outdoor time have been presented as positive predictors of 'flourishing' mental health in youth (Bélanger, Gallant, Doré et al. 2019). Following a survey on a large sample of 7 to 14 year old Canadian children, each additional hour spent outdoors was associated with lower odds of negative psychosocial outcomes compared to children who spend less time outdoors (Larouche, Garriguet, Gunnell et al. 2016). As outdoor time during the school day is limited to break and lunch-times, it is important for children to be able to effectively explore their playground environment, and to enjoy a range of playground activities

The Sport England Active lives CYP (2019) survey identified that children (years 3 to 6 of primary school) who strongly agree that they enjoy taking part in physical activity do 33% more minutes of activity than those who don't enjoy it and report a 50% higher 'happiness' level. The enjoyment scores reported in the Sport England (2019) survey are a reflection of the enjoyment of physical activity outside of school only (no data for inside of school), however highlight the positive effect enjoyment has on physical activity participation. Furthermore, a number of studies have reported the importance of enjoyment as a motivating factor to maintaining engagement in physical activity during physical education in Greek 10 to 17 year olds (Digelidis and Papaioannou, 1999); in Finnish 13 to 15 year olds (Gråstén, Jaakkola, Liukkonen et al. 2002); and UK 14 to 15 year olds (Ntoumanis Pensgaard, Martin, Pipe 2004). However, there is a lack of research exploring he enjoyment of playground activities in UK primary schools.

Enjoyment can drive engagement in physical activity (Sport England, 2019), and we know that children's enjoyment of physical activity decreases as children age (Digelidis and Papaioannou, 1999) with a 12% drop in enjoyment between KS2 and KS3 (Sport England 2019). The lack of enjoyment, and subsequent reduction in physical activity as a child may be due to inappropriate age-related activities or environments. However, the distinction between enjoyment levels between key stages of education is unknown, and therefore warrants further investigation.

The activities and spaces available to children during school break-time are often designed, chosen, and enforced by adults, leading to the creation of play spaces using the method of "seeing through the child's eyes" (Jones 2008). Kellet (2005) suggests a critical limitation to this method is that adults are unable to discard the adult baggage acquired since childhood and therefore operate through an adult filter (conscious or subconscious) often applying principles from their own childhood a decade (or more) ago. The 'adult filter' is often paired with the adult agenda (applying maximum safety principles to avoid injury) leading to a prescription of activities that 'colonise' and 'control' childhood (Jones 2008).

Although there seems to be a genuine attempt from the adult population in the primary school environment to promulgate activities that might be attractive to children (Tremblay et al. 2015) there must be some acknowledgement of the 'unbridgeability' (Jones 2008) between adult and child experiences. Furthermore, there must be a value placed on the insights of children on their adult prescribed activities and the original contribution children can make in choosing and designing their own physical activities (Kellett 2005). Finally, a socio-ecological exploration of playground enjoyment levels will allow a more holistic understanding of the importance of the multiple factors operational in children's activity choices during break-times.

Therefore, the primary aim of this study was to gain a better understanding of children's enjoyment of break-time activities and their satisfaction with the available play spaces in the school playground environment. Secondly, differences between male and female children's enjoyment levels and differences between KS1 and KS2 children were examined to identify any gender and age differences in playground experiences. Finally, the similarities between staff perceptions of children's enjoyment and satisfaction levels and children's own self-reported enjoyment and satisfaction levels were explored.

5.2 Methods

5.2.1 Recruitment

Eight schools from the lowest 10% on the Index of Multiple Deprivation (English indices of deprivation: Department for Communities and Local Government) across the North east of England were contacted with details for the study. Five schools returned expressions of interest and were contacted further to discuss the project requirements. Four schools (including the case study school from chapter 4) returned Head Teacher consent and agreed to allocate time within the school day to complete the questionnaires (School demographics can be seen in Table 5.1). Following ethical approval from the School of Social Sciences, Humanities and Law, research ethics committee at Teesside University (Application number: **SSSBLREC055**; Appendix E) the questionnaires were distributed to senior management at each primary school for content approval. Before participation, staff members wishing to take part in the study were asked to complete informed consent. Similarly, parents and pupils wishing to take part were asked to complete parental consent and assent, respectively.

Table 5.1. Primary school demographics

	Pupils on record (n)	Female/male children (%)	Children in receipt of free school meals (%)
School A	565	51 / 49	47
School B	520	49 / 51	49
School C	303	52 / 48	68
School D	442	47 / 53	33

5.2.2 Participants

Pupils from all year groups (year one to year six) were eligible to complete the questionnaire. Questionnaires were completed between December 2017 and January 2018. Pupils from the younger year groups (5 and 6 years old) were guided by a member of school or research staff. Staff were asked to help interpret questions when asked but not to influence a pupil's response.

All staff members from participating schools were sent an email inviting them to complete the questionnaire. The questionnaire was open to all staff roles within the school.

5.2.3 Questionnaire

A context specific questionnaire, previously validated in Australian elementary school children (8 to 12 years old), (Lunchtime Enjoyment of Activity and Play: LEAP; Hyndman et al. 2013) was adapted (for language and context) and used to assess children's enjoyment and satisfaction levels of their current primary school playground environment. The staff questionnaire consisted of the same questions (context) as the child's questionnaire but from a different perspective. For example, where children were asked to report their enjoyment of climbing, staff were asked to report '*their perception of children's enjoyment'* of climbing.

The questionnaire follows the socio-ecological model (SEM) framework (Davison and Birch 2001) including individual, social and environmental components related to playground use and has been formatted to be suitable for primary school aged children (Salmon and King 2010; Hyndman et al. 2013). The questionnaire takes between ten and fifteen minutes to complete with participants asked to respond using a five point Likert scale with pictorial representation (smiley faces) to signify a range from very unhappy (one on the scale – large frown face) to very happy (five on the scale – large smiley face) (Hyndman et al. 2013). The LEAP questionnaire consisted of sixteen individual items, two social items and eight physical environment items (Hyndman et al. 2013) which account for the multiple factors of the SEM involved in the engagement and enjoyment of the school playground activities (Salmon and King 2010).

5.2.4 Data analysis

As the internal consistency of the original LEAP questionnaire was established in an Australian population of 8 to 12 year olds, we used the same statistical method; Cronbach's alpha (α), to determine the internal consistency of the questionnaire data in our sample (5 to 11 year old UK primary school children). Cronbach's α values were calculated for each of the individual components of the SEM (Tavakol and Dennick 2011) with values above 0.6 considered acceptable (Hyndman et al. 2013). Although Cronbach's α has received criticism as an unfavourable method of measuring internal consistency and/or reliability of psychological and behavioural variables due to unrealistic assumptions (McNeish 2018); a critical appraisal of Cronbach's α and as a consequence further exploratory factor analysis of the LEAP questionnaire is beyond the scope of this thesis.

5.2.4a Individual survey items

Questionnaire responses were entered into Microsoft Excel and coded for gender and age. Children's level of enjoyment was explored descriptively using the proportion of respondents who scored as either 'unhappy' or 'happy' on each of the individual items on the questionnaire. The response categories 'very unhappy' and 'unhappy'; and 'very happy' and 'happy' were combined to get three distinct categories; 'Unhappy', 'Happy' and 'undecided'/'not bothered'.

Gender and age specific enjoyment levels are presented for individual items that resulted in the highest and lowest levels of enjoyment.

5.2.4b Survey score pupils

A survey score for each SEM component was created by taking the average of the Likert responses for each of the model components (individual, social and environmental), giving a score for each participant for each of the SEM components (Sullivan and Artino 2013) using the same five-point scale descriptors. Between group effects for gender (male minus female) in each age group (KS1 and KS2) and the interaction; the difference in male minus female scores for KS1 vs. KS2 was explored for each of the SEM component scores for pupils using a general linear model (univariate ANOVA) with gender (male / female) and age (KS1 and KS2) as factors and SEM component scores as the dependent / outcome variables. Parametric statistics were chosen as Likert scale data can be analysed using parametric statistics without fear of coming to the wrong conclusion (Norman 2010).

Between-group and interaction effects are expressed as mean difference. The uncertainty in the outcomes are presented as 95% confidence limits (CL), giving the range of effect sizes compatible with the data. The outcomes were interpreted as meaningful if the point estimate (mean difference between independent variables and the interaction) and / or the upper and lower limits (95% CL) were above the smallest effect size of interest (SESOI), of half a Likert scale point (0.5 points) and trivial if they fell below half a Likert scale point. Half a point on the scale was chosen for the SESOI as this is the equivalent of moving one point on the Likert scale (rounded up or down). This approach has been used previously (Eley 1992; Lindblom-Ylänne, Trigweel, Nevgi et al. 2006) and preferred over a change of one Likert scale point; as the latter is considered insufficiently discriminating (Eley 1992).

5.2.4c Staff and Pupil comparisons

The difference in the pupils self-reported enjoyment levels for playground activities and the staff self-reported perception of pupil enjoyment levels was the measurement of interest here.

However, as the questions were perceived from a slightly different perspective, the decision was made to run a purely exploratory, descriptive analyses, to identify any differences in the individual item responses on the questionnaire. Survey scores were therefore not calculated for staff responses. Item scores are presented as mean and standard deviation, with group comparisons expressed as mean difference and 95% CL. Comparing the differences using more comprehensive analytic methods would assume the groups were directly comparable and from an equal sample size.

5.3 Results

5.3.1 Internal consistency of the LEAP

The Cronbach's α values for the SEM components of the LEAP questionnaire for children and staff can be seen Table 5.2. All components met acceptable levels (≥0.6) excluding the social component for children and staff (0.3 and 0.6, respectively)

5.3.2 Participant engagement

A total of 286 pupils (47% female) and 18 members of staff (67% female) across the four schools completed the questionnaire in full. The contribution from each staff role and from each year group can be seen in Table 5.3.

Table 5.2. Internal consistency (Cronbach's alpha) for the LEAP questionnaire components for pupils and staff

		Pupil	Staff
SEM component	Number of items	Cronbach's *α* (95%CI)	Cronbach's *α* (95%CI)

Individual	16	0.8 (0.7 to 0.8)	0.9 (0.7 to 0.9)
Social	2	0.3 (0.1 to 0.4)	0.5 (0.4 to 0.8)
Environmental	8	0.6 (0.5 to 0.6)	0.6 (0.2 to 0.8)

Abbreviations: α = Cronbach's alpha; CI = Confidence interval; LEAP = Lunchtime Enjoyment of activity and Play; SEM = Socio-ecological model

Table 5.3. Participant characteristics: group contributions

	Number of responses		Number of responses
Pupil Year		Staff Role	
Year 1	28	Teacher	9
Year 2	44	Principal/Management	3
Year 3	46	Specialist teacher (behaviour lead)	3
Year 4	28	Sports coach	1
Year 5	88	Administrator	2
Year 6	52		
Total	286		18

5.3.3 Socio-ecological model – component levels of enjoyment

The mean difference in male minus female scores for individual, social and environment components were trivial at both KS1 and KS2 (Table 5.4). The upper 95% CL for individual and social factors at KS1 was equivalent to the SESOI. The interaction between the difference in male minus female scores at KS1 and KS2 for all SEM components were considered trivial. The upper 95% CL for individual and social factors were equivalent or exceeded the SESOI with a difference between male and females scores between the age groups. The lower 95% CL for the environmental component was equivalent to the SESOI with a difference between male and female scores between age groups noted.

Table 5.4. Between group effects for enjoyment of playground activities

	Male	Female	Mean difference (95% CL)	Interaction (95% CL)	R^2
Individual	Mean ± SD				
KS1	3.8 ± 0.6	3.6 ± 0.6	0.2 (-0.1 to 0.5)	0.2 (-0.1 to **0.6**)	0.02

KS2	3.5 ± 0.6	3.5 ± 0.7	-0.03 (-0.2 to 0.1)		
Social					
KS1	4.3 ± 1.0	4.2 ± 1.0	0.1 (-0.2 to 0.5)	0.1 (-0.3 to **0.5**)	0.04
KS2	4.5 ± 0.7	4.5 ± 0.6	-0.02 (-0.2 to 0.2)		
ENVIROMENTAL					
KS1	3.7 ± 0.9	3.7 ± 0.7	-0.1 (-0.4 to 0.2)	-0.2 (**-0.5** to 0.2)	0.004
KS2	3.7 ± 0.6	3.6 ± 0.6	0.1 (-0.1 to 0.3)		

Abbreviations: KS = key stage; CL = confidence limits;

5.3.4 Item level differences

Gender and age group differences in self-reported enjoyment can be explored in Table 5.5 and Table 5.6, respectively. The highest levels of enjoyment reported for males and females and by each age group is described below under the relevant SEM level descriptors.

- *Individual level*

Males self-reported that “being active”, “playing”, and “running” gave them the highest levels of enjoyment at break-times (84%, 87% and 88%, respectively). Female’s highest self-reported levels of enjoyment at break-times were “being active” (78%), “playing” (78%), “climbing” (75%) and “playing chase/tag” (69%). Males and females self-reported “sitting” (49%) and “playing alone” (21.7% and 14.9%, respectively) gave them the least enjoyment at break-times.

Key stage 1 and 2 children self-reported “being active” (88% and 79%, respectively), “playing” (82% and 83% respectively), and “running” (79%) gave them the highest levels of enjoyment at break-times. In addition, “playing chase games” (78%) and “being creative and making things” (78%) had a higher self-reported level of enjoyment for KS1 children during break-times. KS1 and KS2 children self-reported low levels of enjoyment for “sitting in the playground” (32% and 31%, respectively) during break-times. In addition, KS2 children self-reported low levels of enjoyment for “playing alone” (12%) at break-times.

- *Social level*

Males and females both self-reported “playing with friends” (90% and 91%, respectively) and “talking with friends” (78% and 81%, respectively) gave them the highest levels of enjoyment at the social level.

Key stage 1 and 2 children both self-reported “playing with friends” (86% and 92%, respectively) and “talking with friends” (72% and 82%, respectively) gave them the highest levels of enjoyment at the social level.

- *Environmental*

Males and females both self-reported “playing on grassy areas” (67% and 64%, respectively), “using sports equipment” (72%), and “using move-able playground equipment” (67% and 66%, respectively) gave them the highest levels of enjoyment during break-times. In addition, “playing on hard surfaces” had a higher self-reported level of enjoyment for males (64%) during break-times. Self-reported, lowest levels of enjoyment for males and females was “using fixed playground equipment” (42% and 47%, respectively).

Key stage 1 and 2 children both self-reported “using move-able playground equipment” (65% and 67%, respectively) gave them the highest levels of enjoyment during break-times. In addition, “playing on grassy surfaces” (68%) and “using sports equipment” (74%) had a higher self-reported level of enjoyment for KS2 children during break-times, whilst “”playing on hard surfaces” (71%) and “changing where you play” (64%) had a higher self-reported level of enjoyment for KS1 children during break-times. The highest levels of unhappiness were reported for “the size of your playground” (36%) and “using fixed playground equipment” (32%) for KS1 and KS2, respectively.

Table 5.5. Male and Female scores on the LEAP questionnaire for individual, social and environmental levels of enjoyment of playground activities

SEM components						
Individual **At school break-time, how much do you enjoy:**	**Gender**	**VU %**	**U %**	**NS %**	**H %**	**VH %**
being active?	Male	2.6	3.3	9.9	22.4	61.8
	Female	2.2	3.7	16.4	18.7	59.0
playing at break-time?	Male	2.0	2.6	8.6	14.5	72.4
	Female	4.5	3.7	13.4	24.6	53.7
sitting in the playground?	Male	34.9	14.5	21.1	10.5	19.1
	Female	35.8	13.4	17.9	14.9	17.9
using your imagination?	Male	15.8	5.3	17.8	17.1	44.1
	Female	11.2	14.2	19.4	13.4	41.8
playing alone?	Male	56.6	12.5	9.2	6.6	15.1
	Female	63.4	10.4	11.2	4.5	10.4
changing what you play?	Male	13.2	10.5	21.1	19.7	35.5
	Female	13.4	11.2	17.9	20.9	36.6
playing chase games?	Male	8.6	5.9	10.5	14.5	60.5
	Female	9.0	7.5	20.1	25.4	38.1
sitting/relaxing?	Male	29.6	11.8	16.4	7.2	34.9
	Female	23.9	11.9	19.4	13.4	31.3
walking?	Male	28.3	17.8	17.8	11.8	24.3
	Female	20.9	15.7	14.2	17.2	32.1

jogging?	Male	17.1	13.8	19.7	18.4	30.9
	Female	14.9	12.7	26.9	18.7	26.9
running?	Male	6.6	2.0	3.9	12.5	75.0
	Female	3.7	8.2	19.4	15.7	53.0
climbing?	Male	19.7	4.6	7.2	13.2	55.3
	Female	9.0	6.7	9.7	22.4	52.2
jumping?	Male	19.1	5.3	19.7	19.1	36.8
	Female	13.4	10.4	17.2	23.9	35.1
hanging?	Male	24.3	6.6	12.5	12.5	44.1
	Female	19.4	6.7	10.4	12.7	50.7
throwing things? (tennis balls, bean bags, etc.)	Male	14.5	9.9	9.9	13.8	52.0
	Female	21.6	7.5	14.9	20.1	35.8
being creative and making things? (blocks, shows etc.)	Male	15.1	11.8	10.5	10.5	52.0
	Female	7.5	8.2	11.9	9.0	63.4
Social **At school break-time how much do you enjoy:**	**Gender**	**VU %**	**U %**	**NS %**	**H %**	**VH %**
playing with your friends?	Male	0.7	3.3	6.6	8.6	80.9
	Female	2.2	0.7	6.0	14.9	76.1
talking with friends?	Male	5.9	3.3	12.5	15.1	63.2
	Female	3.7	6.7	8.2	23.1	58.2

Environmental **A school break-time how much do enjoy:**	**Gender**	**VU %**	**U %**	**NS %**	**H %**	**VH %**
changing where you play?	Male	12.5	11.2	25.0	21.1	30.3
	Female	17.2	8.2	23.9	25.4	25.4
playing on grassy areas?	Male	12.5	7.9	12.5	28.3	38.8
	Female	8.2	12.7	14.9	23.9	40.3
playing on hard surfaces?	Male	10.5	5.9	19.7	27.0	36.8
	Female	12.7	7.5	32.1	14.2	33.6
using sports equipment? (balls, rackets, pitches)	Male	9.9	6.6	11.2	13.8	58.6
	Female	9.0	6.7	12.7	14.2	57.5
using fixed playground equipment? (climbing frames, markings etc.)	Male	17.8	11.8	28.3	16.4	25.7
	Female	15.7	14.2	23.1	22.4	24.6
using moveable playground equipment? (bikes, scooters, skipping ropes, etc.)	Male	13.8	7.2	11.8	13.2	53.9
	Female	14.2	4.5	15.7	16.4	49.3
Environmental **A school, how happy are you with:**						
the size of your school playground?	Male	15.8	9.2	13.8	13.8	47.4
	Female	11.9	9.0	11.9	18.7	48.5
The amount of things within your school playground you can play with?	Male	9.2	7.9	18.4	13.2	51.3
	Female	13.4	11.9	14.2	12.7	47.8

Abbreviations: SEM = socio-ecological model; VU = very unhappy; U = unhappy; NS = not sure; H = happy; VH = very happy

Table 5.6. Key stage 1 and 2 scores on the LEAP questionnaire for individual, social and environmental levels of enjoyment of playground activities

SEM components						
Individual **At school break-time, how much do you enjoy:**	**Age group**	**VU %**	**U %**	**NS %**	**H %**	**VH %**
being active?	KS1	4.2	2.8	5.6	22.2	65.3
	KS2	1.9	3.7	15.4	20.1	58.9
playing?	KS1	6.9	2.8	8.3	18.1	63.9
	KS2	1.9	3.3	11.7	19.6	63.6
sitting in the playground?	KS1	36.1	12.5	19.4	6.9	25.0
	KS2	35.0	14.5	19.6	14.5	16.4
using your imagination?	KS1	9.7	11.1	13.9	16.7	48.6
	KS2	15.0	8.9	20.1	15.0	41.1
playing alone?	KS1	47.2	6.9	13.9	8.3	23.6
	KS2	64.0	13.1	8.9	4.7	9.3
changing what you play?	KS1	15.3	12.5	6.9	9.7	55.6
	KS2	12.6	10.3	23.8	23.8	29.4
playing chase games?	KS1	12.5	2.8	6.9	9.7	68.1
	KS2	7.5	7.9	17.8	22.9	43.9
sitting/relaxing?	KS1	23.6	5.6	12.5	9.7	48.6
	KS2	28.0	14.0	19.6	10.3	28.0
walking?	KS1	22.2	13.9	13.9	15.3	34.7
	KS2	25.7	17.8	16.8	14.0	25.7

jogging?	KS1	20.8	9.7	18.1	13.9	37.5
	KS2	14.5	14.5	24.8	20.1	25.2
running?	KS1	5.6	6.9	8.3	12.5	66.7
	KS2	5.1	4.2	12.1	14.5	64.0
climbing?	KS1	15.3	5.6	6.9	19.4	52.8
	KS2	14.5	5.6	8.9	16.8	54.2
jumping?	KS1	19.4	5.9	16.7	16.7	41.7
	KS2	15.4	8.4	19.2	22.9	34.1
hanging?	KS1	26.4	2.8	18.1	11.1	41.7
	KS2	20.6	7.9	9.3	13.1	49.1
throwing things? (tennis balls, bean bags, etc.)	KS1	29.2	6.9	4.2	15.3	44.4
	KS2	14.0	9.3	15.0	17.3	44.4
being creative and making things? (blocks, shows etc.)	KS1	9.7	6.9	5.6	8.3	69.4
	KS2	12.1	11.2	13.1	10.3	53.3
Social **At school break-time how much do you enjoy:**	**Age group**	**VU %**	**U %**	**NS %**	**H %**	**VH %**
playing with your friends?	KS1	4.2	4.2	5.6	9.7	76.4
	KS2	0.5	1.4	6.5	12.1	79.4
talking with friends?	KS1	13.9	5.6	8.3	18.1	54.2
	KS2	1.9	4.7	11.2	19.2	63.1

Environmental **A school break-time how much do enjoy:**	**Age group**	**VU %**	**U %**	**NS %**	**H %**	**VH %**
changing where you play?	KS1	18.1	2.8	15.3	23.6	40.3
	KS2	13.6	12.1	27.6	22.9	23.8
playing on grassy areas?	KS1	16.7	11.1	13.9	13.9	44.4
	KS2	8.4	9.8	13.6	30.4	37.9
playing on hard surfaces?	KS1	8.3	5.6	15.3	16.7	54.2
	KS2	12.6	7.0	29.0	22.4	29.0
using sports equipment? (balls, rackets, pitches)	KS1	20.8	4.2	8.3	9.7	56.9
	KS2	5.6	7.5	13.1	15.4	58.4
using fixed playground equipment? (climbing frames, markings etc.)	KS1	13.9	8.3	16.7	16.7	44.4
	KS2	17.8	14.5	29.0	20.1	18.7
using moveable playground equipment? (bikes, scooters, skipping ropes, etc.)	KS1	19.4	6.9	8.3	11.1	54.2
	KS2	12.1	5.6	15.4	15.9	50.9
Environmental **A school, how happy are you with:**						
the size of your school playground?	KS1	22.2	13.9	5.6	18.1	40.3
	KS2	11.2	7.5	15.4	15.4	50.5
The amount of things within your school playground you can play with?	KS1	16.7	6.9	16.7	16.7	43.1
	KS2	9.3	10.7	16.4	11.7	51.9

Abbreviations: SEM = socio-ecological model; KS1 = Key stage 1; KS2 = Key stage2; VU = very unhappy; U = unhappy; NS = not sure; H = happy; VH = very happy

5.3.5 Staff and pupil comparison

The staff and pupil responses to each item (mean ± SD) can be seen in Table 5.7. The mean differences are interpreted against the SESOI of 0.5 Likert points. Meaningful individual level item differences (Mean; 95% CL) were noticeable for “using your imagination” (0.5; 0.0 to 1.1), “jogging” (0.6; 0.04 to 1.2), “running” (0.9; 0.3 to 1.5), “hanging” (0.5; -0.1 to 1.1) and “being creative and making things” (0.5; -0.04 to 1.1). A meaningful social level item differences was noted for “talking with friends” (0.8; 0.3 to 1.3). At the environmental levels, differences in “changing where you play” (0.7; 0.4 to 1.1), “using sports equipment” (-0.8; -1.1 to -0.4), “using fixed playground equipment” (-0.6; -1.1 to -0.2) and satisfied with “the amount of things in your playground” (0.9; 0.1 to 1.6), were noted above the SESOI.

Table 5.7. Pupil and staff differences for individual LEAP items (pupils minus staff)

	Pupil	**Staff**	**Effect above SESOI, (Mean difference; 95%CL)**
Individual: At school break-time how much do you enjoy:			
Being active?	4.3±1.0	4.2±0.6	No (0.2; -0.16 to 0.49)
Playing at break-time?	4.4±1.0	4.3±0.5	No (0.04; -0.23 to 0.30)
Sitting in the playground?	2.7±1.5	2.7±0.7	No (-0.1; -0.44 to 0.30)
Using your imagination?	3.7±1.5	3.1±1.0	**Yes (0.5; 0.01 to 1.1)***
Playing alone?	2.0±1.5	2.2±1.0	No (-0.2; -0.68 to 0.35)
Changing what you play?	3.5±1.4	3.3±0.7	No (0.2; -0.16 to 0.59)
Playing chase games?	4.0±1.3	4.1±0.8	No (-0.1; -0.52 to 0.32)
Sitting/relaxing?	3.1±1.6	3.0±0.9	No (0.1; -0.38 to 0.59)
Walking?	3.0±1.6	2.6±1.0	No (0.4; -0.11 to 0.97)
Jogging?	3.3±1.4	2.7±1.2	**Yes (0.6; -0.04 to 1.2)***
Running?	4.3±1.2	3.4±1.1	**Yes (0.9; 0.31 to 1.5)***
Climbing?	3.9±1.5	3.9±0.9	No (-0.04; -0.50 to 0.42)
Jumping?	3.5±1.5	3.4±0.9	No (0.1; -0.37 to 0.54)
Hanging?	3.6±1.6	3.1±1.1	**Yes (0.5; -0.07 to 1.1)***
Throwing things? (Tennis balls, bean bags, etc.)	3.6±1.5	3.9±0.9	No (-0.3; -0.83 to 0.16)
Being creative and making things?	3.9±1.5	3.4±1.1	**Yes (0.5; -0.04 to 1.1)***
Social: At school break-time how much do you enjoy:			
Playing with friends	4.6±0.8	4.3±0.6	No (0.3; -0.001 to 0.61)
Talking with friends	4.3±1.1	3.4±1.0	**Yes (0.8; 0.31 to 1.3)**

Environmental: A school break-time how much do enjoy:			
Changing where you play?	3.6±1.3	2.9±0.7	**Yes (0.7; 0.37 to 1.1)***
Playing on grass?	4.1±1.3	4.4±1.0	No (-0.4; -0.91 to 0.11)
Playing on hard surfaces?	3.2±1.4	3.6±0.6	No (-0.4; -0.72 to -0.04)
Using sports equipment?	3.8±1.5	4.6±0.6	**Yes (-0.8; -1.1 to -0.43)***
Using fixed playground equipment?	3.8±1.5	4.4±0.8	**Yes (-0.6; -1.1 to -0.23)***
Using moveable equipment?	3.8±1.4	4.2±0.8	No (-0.4; -0.79 to 0.05)
Environmental: At school, how happy are you with:			
The size of your playground?	3.4±1.4	3.2±1.2	No (0.2; -0.38 to 0.85)
The amount of things in your playground?	3.7±1.3	2.9±1.4	**Yes (0.9; 0.14 to 1.6)***

5.4 Discussion

The aim of this study was to explore children's level of enjoyment of break-time activities from an ecological perspective. Pupils from participating schools were asked to rate their enjoyment and satisfaction with the break-time activities available to them and the play spaces in their school playground. The enjoyment levels were compared for male and female children. In addition, the difference in enjoyment levels between males and females was compared between the age groups (KS1 and KS2) in order to explore any interaction effects. Finally, staff were asked to rate their perception of pupil's enjoyment and satisfaction with break-time activities. The staff levels of perceived enjoyment and pupil self-reported enjoyment were then compared to explore any individual item differences

A key finding from this study was that, similar to previous socio-ecological explorations of children's play activities (Coulter and Woods 2011; Hyndman and Chancellor 2015; Hyndman and Lester 2015) pupil's highest level of enjoyment (independent of gender and age) was at the social level.

The proportion of males and females self-reporting as 'happy' (≥ 3 on the scale) for the items 'playing with friends' (90% and 91%, respectively) and 'talking with friends' (72% and 82%) were very similar to Hyndman and Chancellor (2015) ('playing with friends' 96% and 100%; 'talking with friends' 82% and 88%, for males and females respectively). The high levels of enjoyment are not surprising as social play and friendship, play an essential role in giving children the confidence to explore the playground environment and establish their potential (Jones and Okely 2011). Also, ‘playing with friends’ presents opportunities to affirm friendships initiated in other contexts within the school environment (Coakley 1993). Hyndman and Lester (2015) reported similarly high levels of enjoyment for the social level playground variables. However, the authors also revealed a lack of any significant relationship between children’s enjoyment of social play and physical activity participation.

Males and females in this current study scored equally for their enjoyment of ‘playing with friends’ (90% and 91%, respectively). However, the opportunity to socialise is often considered an activity pursued more by females than males (Pellegrini and Holmes 2006). Findings from the previous chapter (chapter 4) in this thesis which observed children in the primary school playground would support this claim with a higher percentage of female children observed in area’s that promoted social interaction. Therefore, one might infer that female preference for socialising seems to be explained more by the opportunities to simply socialise with friends rather than being able to play with them. This is evident in a higher level of enjoyment for “talking with friends” for females in this study.

Focus groups with children have highlighted that the presence of friends/peers can have an influence on the activity levels of female children (Hyndman et al. 2012). Likewise, the ability to catch-up with friends and talk was a bigger driver to seek out friends at break-time than to engage in group physical activities:

> *“People have more fun when they are talking with their friends, cause lunchtime and recess are the only times for that”* (Female participant; Hyndman et al. 2012; pg.11)
>
> *“Me and my friends hang out under the stairs because it’s nice and quiet so we can talk to each other”* (Female participant; Hyndman et al. 2012; pg.12)
>
> *“Sometimes the boys bring footballs on the playground and it’s really annoying”* (Female participant; Hyndman et al. 2012; pg.9)

The desire for females to seek out quiet areas for talking and to avoid the more active pursuits explored by the males on the playground can act as a barrier to their enjoyment of playground activities, and consequently their physical activity participation.

Hyndman and Chancellor (2015) previously reported female pupils more frequently mix and make friends with children from all ages, whilst males do not. Although there were differences in the proportion of pupil's self-reporting as either 'happy' or 'very happy' for social items ('talking with friends') on the questionnaire in this study, when combining the items and analysing the underlying SEM construct (social level enjoyment) there were trivial mean differences in survey score noted between males and females. However, it is more common for children of younger primary school ages (5 and 6 years old) to engage in activities as a mixed-gender group, and as they move through the primary school years, they are more likely to form exclusive gender groups (Maccoby 2002). The schools participating in this study had separate playgrounds for KS1 and KS2 pupils, which is common in UK primary schools. The KS2 playgrounds were largely open fields and tarmac with little added facilities, whilst the KS1 playgrounds had a larger range of possible playground activities. It is possible that exclusive gender groups are formed as children age as a consequence of the environments available to them and the activities they promote.

Nonetheless, the age related development in gender group formation would suggest that differences in the male and female enjoyment levels in this study across the SEM components may be more noticeable as children age. However, when examining the interaction (difference in male minus female scores at KS1 and KS2) at the social levels of the SEM, the point estimate (the difference between males minus females at KS1 and KS2) was trivial (≤0.5 Likert points). Furthermore, when examining the interaction at each of the additional SEM levels (individual and environmental), the difference between males and females at KS1 and KS2 were also trivial (≤0.5 Likert points) (Table 5.4).

Although each item in the LEAP survey was grouped using the SEM components, as Hyndman and colleagues have previously done, to analyse the enjoyment of activities from each of the underlying constructs (individual, social and environmental enjoyment), the survey outcomes in this study might have been influenced by the inclusion of two younger year groups (5 to 6 and 6 to 7 year olds). Hyndman et al. (2013) original validation of the LEAP was in children 8 years old and above. The tendency for the younger children in this study to endorse responses at the extreme end of the scales (Chambers and Johnston 2002), might have resulted in an unrefined measure of each SEM component (Mellor and Moore 2014). This might have led to an underestimation in the interactions presented above. With that said, the confidence limits for individual, social and environmental components were 0.6 (upper CL), 0.5 (upper CL) and -0.5 (lower CL) Likert points, respectively. Therefore, a meaningful interaction (equivalent to or greater than the SESOI of 0.5 Likert points) between the male / female difference in survey scores at KS1 and KS2 cannot be significantly ruled out.

Subtle gender and age group differences become more apparent when exploring survey items individually (Table 5.5 and Table 5.6). For example, there was a high proportion of male pupils scoring “running” (88%) (Individual) and “playing on hard surfaces” (64%) (Environmental) as giving them higher levels of enjoyment during break-times compared to females (64% and 48%, respectively). The enjoyment of “climbing” (75%) and “being creative and making things” (72%) (social) during break-times scored more highly with female pupils compared to males (68% and 62%, respectively). As others have suggested, the playground can be a place of fear for many children, a visible arena where gender identities are formed, destroyed and contested (Renold 1997), bolstered by the pre-arranged hierarchy of available space, with football often monopolising the available space, a playground activity historically dominated by males (Renold 1997). In all of the schools included in this study, one half to two thirds of the available play space was either formally or informally classified as football space, with smaller clusters of social spaces, creative spaces (sand pits, stages, reading areas) and playground markings making up the other options available to the children. The differences noted in this study may actually under-estimate the gender difference in the enjoyment of playground activities given that self-reported enjoyment presented here is a manifestation of children's responses to their current playground experiences/opportunities. Nevertheless, children in this study self-report enjoyment of these available activities and value should be placed on this outcome due to the mediating effect of enjoyment on physical activity levels (Dishman, Motl, Saunders et al. 2005).

Likewise, when considering the effect of age on enjoyment levels we observed that KS1 children had a higher self-reported enjoyment level for "playing on hard surfaces" (71%) (environmental), "playing chase games" (78%) (individual), "being creative and making things" (78%) (individual) and "changing where you play" (64%) (environmental) compared to KS2 (51%, 66%, 64% and 46%, respectively). Whilst KS2 enjoyed "playing on grassy surfaces" (68%) and "using sports equipment" (74%) (environmental) compared to KS1 (58% and 66%, respectively). Item level age differences presented here are similar to those from Hyndman and Chancellor (2015) who found older children are less likely to change where they play or play creatively during break-times. Differences between KS1 and KS2 are important when seeking to understand the level of enjoyment for the activities so that age appropriate playground activities can be provided.

It has been suggested that over time primary school children could have a reduced interest in exploring their playground environment because they have formed more 'routine play' behaviours and therefore less likely to enjoy changing and creatively developing school play activities (Hyndman and Chancellor 2015). Conversely, the KS1 playgrounds from included schools were predominantly surfaced in concrete with playground markings, whilst the KS2 playgrounds were predominantly grassy with concrete areas marked (and sometimes fenced) promoting the very activities children self-reported enjoying the most. The age groups findings from the current study might be best interpreted as an indicator of the enjoyment of playground activities currently provided in the separated KS1 and KS2 playgrounds. However, it is important to establish if the enjoyment levels reported here and in previous school playground studies are contributing to the age related decline in physical activity levels (Cooper et al. 2015; Farooq et al. 2017) by a lack of age and developmentally appropriate playground activities being provided.

Previous playground observations have highlighted differences between the way male and female children use the playground with male children generally using break-times to engage in more vigorous physical activities involving competitive games and sports and are more active on areas with hard surfaces, whilst female children are more likely to engage in activities considered light physical activity, such as social play and the use of movable play equipment (Anthamatten et al. 2014; Hyndman, Benson and Telford 2014; Reimer, Schoeppe, Demetriou, Knapp 2018). Moreover, previous research has found that male children engage in a higher amount of MVPA in the playground (Anthamatten et al. 2014; Hyndman et al. 2014). However, in the current study, female children reported a high level of enjoyment for “being active” and “playing chase/tag” and self-reported a low level of enjoyment for the more inactive playground activities (“sitting”, “relaxing”, “walking”), suggesting that female children enjoy participating in higher intensity physical activity also. These findings are important, as enjoyment levels are a key determinant in the physical activity levels of children (Welk 1999). An acknowledgement from school policy makers to provide the environment needed to promote more of the activities reported with the highest levels of enjoyment would increase the likelihood of children (male and female) engaging in higher amounts of MVPA during break-times.

Until now it was unclear whether children adopted the previously observed behaviours as a result of the physical constraints on the playground (Anthamatten et al. 2014), because of the challenging negotiation and acceptance of gendered boundaries (Renold 1997) or because more simply, the pupils enjoyed using these areas and the activities promoted within. The self-reported enjoyment of playground activities highlighted here demonstrate that there are subtle (individual item) differences in the preferred activities for male and female primary school pupils. However, female children’s self-reported high levels of enjoyment for more active playground behaviours is contrary to current playground observations and justifies further investigation.

Children often experience a playground designed, prescribed and managed in line with an adult agenda (safety and behaviour management) with a genuine attempt to prescribe activities that the children will engage with and enjoy. An important finding from this study is the discrepancy between pupils self-reported enjoyment levels and the staff perception of pupil enjoyment at break-times. Differences larger than half a Likert scale point were noted for individual items across all of the SEM levels. However, the opportunity to socialise ("talking with friends"), be flexible in the area of play ("changing where you play") and access a variety of play spaces ("the amount of things in your playground") were all scored as providing a higher level of enjoyment by pupils than was perceived by the staff (mean difference of 0.8, 0.7, and 0.9 Likert points, respectively). Furthermore, staff perceived "using sports equipment" (-0.8; -1.1 to -0.4), and "using fixed playground equipment" (-0.6; -1.1 to -0.2) as providing higher levels of enjoyment than was reported by the pupils.

As highlighted previously, adult prescribed activities represent a genuine attempt to promote effective engagement with the play spaces available (Tremblay et al. 2015). However, this study reinforces the potential magnitude that the 'adult-filter' might have on the pupil's levels of enjoyment and the future design and prescription of playground activities (Kellett 2005). For example, staff were under the impression that children were "not bothered" (three on the Likert scale) with "*the amount of things"* available in the school playground whilst children scored almost a full Likert point higher (0.9; 0.14 to 1.6) reporting they were "happy" on this item (four on the Likert scale). School staff have the power and responsibility to make the school playground an inclusive and enjoyable space for all pupils. However, incongruity between the staff perception of enjoyment and pupil's actual enjoyment has the potential to lead to counterintuitive changes to the geography of the playground, evident in the provision of equipment outcomes from chapter 3 (providing equipment led to decreases in physical activity levels).

These findings reinforce the importance of the inclusion of the child in the design, management and prescription of activities for child spaces (Kellett 2005) to ensure playground activities are enjoyable and promote a higher amount of physical activity.

5.4.1 Strengths, limitations and future directions

This aim of this study was to gain an understanding of the enjoyment of playground activities and play spaces at a primary school level during break-times. The large sample size and use of a survey encompassing core aspects of the socio-ecological influences of health add value to the outcomes presented here. However, despite the previous validation of the LEAP survey, the social level alpha values in this study were below an acceptable level (Hyndman et al. 2013). It has been previously explained that lower reliability of social items should be expected due to the limited number of items for this component (two items) (Hyndman et al. 2013). However, the alpha levels reported may be partly explained by the inclusion of younger year groups in this study than in the previous studies using the LEAP (Hyndman et al. 2013; Hyndman and Chancellor 2015; Hyndman and Lester 2015) and an inaccurate interpretation of survey items. Despite this, the sensitive navigation of the primary school playground results in a relatively unstable social environment (Renold 1997) and the level of scrutiny involved in peer acceptance influences a child's social well-being (Hyndman et al. 2013) which might also explain some of the issues with the internal consistency reported here.

The scale used in this study had three sub-categories (individual, social and environmental), with items in each category measuring the same underlying construct. However, there is a growing belief that the use of Cronbach's α fails to accurately establish the true degree of precision for a scale as the factor loadings from each individual item are not likely to be equivalent (Yang and Green 2011; McNeish 2017). The effect of this and other drawbacks of the use of Cronbach's α to establish reliability of the LEAP scale warrants cautious interpretation of the survey totals reported. Furthermore, the low R^2 values suggest that the regression model for the interaction between gender and year group is only weakly compatible with the data. Therefore, the aforementioned, in addition to the survey scores provided; as is the recommended method for analysing surveys using Likert scales measuring some underlying construct, we explored individual items from each of the SEM components to ensure that some of the more discrete differences between genders and age were identified.

The validation of Kellett (2005) 'adult filter' presented in this study is a valuable insight into the inaccurate adult embodiment of childhood. Despite slight dissimilarities in the survey approach, the discrepancy between the self-reported levels of enjoyment of the pupils and the perception of pupil enjoyment by the staff cannot be overlooked.

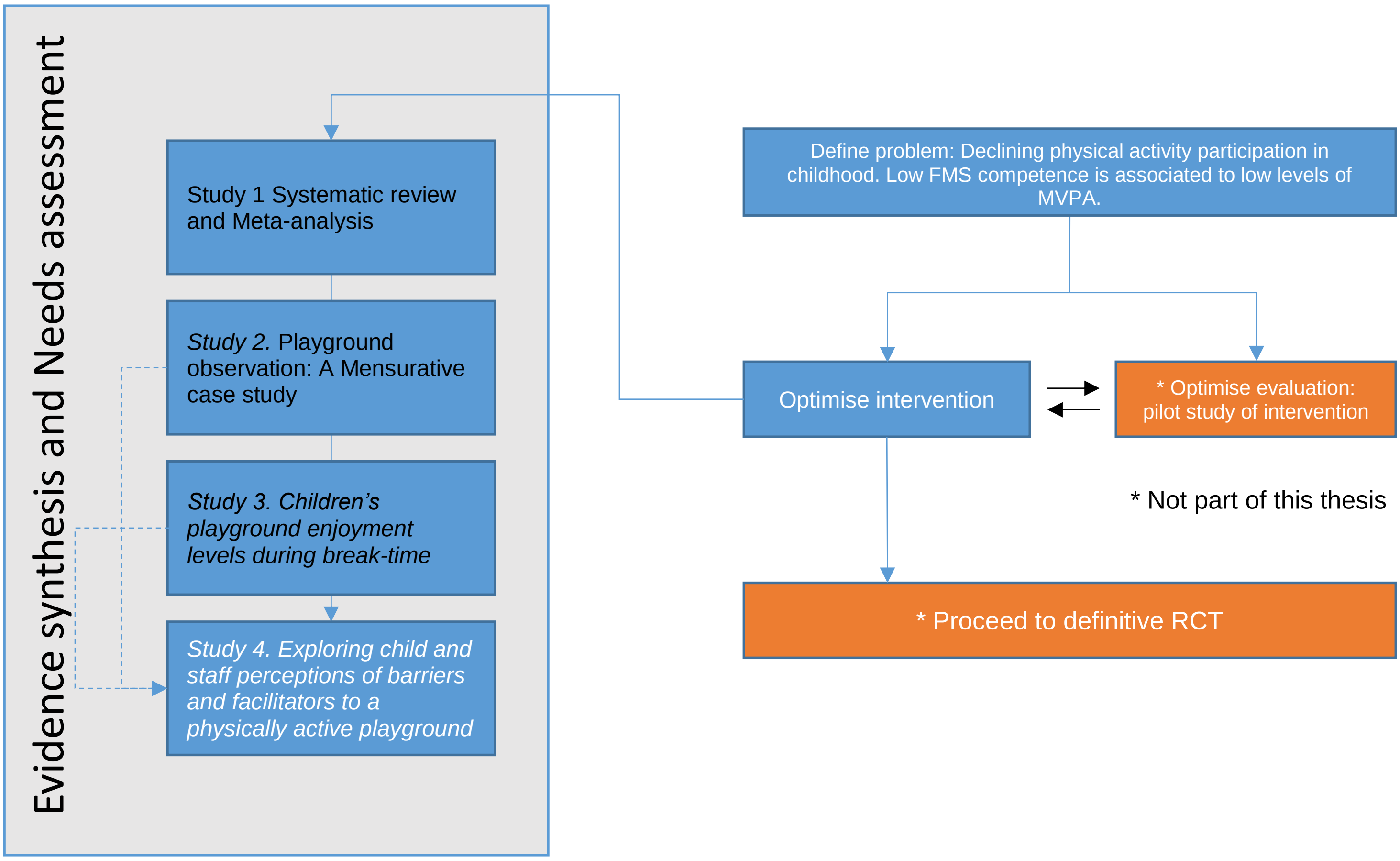
Finally, it is often the case in schools that, due to the weather in the winter months, access to the grassy areas is prohibited, driving the dominant activities from these larger spaces on to the other areas of the playground. This causes conflict between predominantly male and female pupils often causing female pupils to withdraw to the evermore restricted areas of the playground. The pupils in this study completed the survey in the months of December and January so the findings from the current study may be a more accurate representation of the winter school playground. Future work should consider an assessment of playground enjoyment at different times throughout the school year to contribute to a more holistic assessment of playground enjoyment levels.

5.5 Conclusion and PhD implications

The combination of playground observations and children's self-reported enjoyment of playground activities gives some insight into how gender operates on the school playground (Anthamatten et al. 2014) and highlights the need for a consideration of the needs of all pupils in making the playground an enjoyable play space. The item level differences between KS1 and KS2 are best interpreted as a reflection of pupils' enjoyment of the playground environments currently available to them (i.e., higher scores for the surface type they predominantly have access to). The incongruity between child and adult responses at the individual ('using imagination', 'running', 'hanging', 'being creative…'), social ('talking with friends') and environmental ('changing where you play', 'using sports equipment', 'using fixed playground equipment', 'the amount of things to do on the playground') levels must be acknowledged when considering changes to the playground environment and future playground designs.

The findings from this study contribute to the insight from previous observations (chapter 4) and help to explain some the reasons children choose to occupy particular playground areas. However, the discrete differences between male and female children in enjoyment levels and the use of the different playground spaces available to children during break-times may be affected by how accessible they are to different genders. Future work in this thesis will use the observations and questionnaire responses from chapter 4 and 5, to explore some of the barriers and facilitators of the playground spaces available to children during break-times. The aim of the following qualitative exploration was to assess the accessibility to different playground areas and the physical activity choices available to male and female children during break-time. Outcomes from each of the chapters in this thesis can then be combined and applied to future playground intervention planning (chapter 8), creating a physically active environment that is equally accessible, enjoyable and positive for all playground users. Chapter 8 will explain the process of intervention development, identify key components to the proposed intervention and cross reference to which chapter outcomes (thesis) each of the intervention components addresses.

CHAPTER 6: A QUALITATIVE EXAMINATION OF PUPIL AND STAFF PERCEIVED BARRIERS AND FACILITATORS TO A PHYSICALLY ACTIVE PLAYGROUND DURING BREAK AND LUNCH-TIMES IN A PRIMARY SCHOOL SETTING



Chapter aim: Determine playground users (school staff and pupil) perceptions of the current school playground and the barriers and facilitators to a physically active school playground.

Study design: Qualitative using deductive thematic analysis

Key findings: To the author's knowledge, this is the first socio-ecological investigation of the UK primary school playground environment that has identified barriers and facilitators of physical activity at each level of the SEM. Social interaction (friendship and peer acceptance) is an important facilitator to physical activity engagement and FMS development. Barriers and facilitators were identified at all levels of the socio-ecological model and important interactions between levels were evident. There are differences in the child and adult perceptions of the playground (different agendas), and traditional playground hierarchies act to promote and prevent physical activity engagement for different groups (hegemonic masculinity).

6.1 Introduction

Break-times are reported to be the most favourable periods of the day for children (Baines and Blatchford 2019a), providing periods of time for children to catch up with their friends (Mulryan-Kyne 2014) which can positively impact on the integration and adjustment to the school environment (Blatchford, Pellegrini and Baines 2016, pg.6). However, Baines and Blatchford (2019a) suggest schools and policy makers disagree with child perceptions about the value and function of break-times, perceived by adults as predominantly a relatively unimportant pause in an otherwise busy day, solely used to reduce undesirable behaviour. Despite the damaging adult perspective of break-times role in a child's day (for example, removing time for socialising, and freedom), children's enjoyment levels of their break-times and their school playground are predominantly positive (thesis, chapter 5; Mulryan-Hyne 2014).

Mulryan-Kyne (2014) suggested break-times are a rare period in the day where children can choose how to spend their time, interact freely with their peers and be relatively free from adult control, with outdoor play associated with fun and relaxation. However, the 'free' play behaviours of children can be shaped by the contexts in which they are placed, and the wider geography of the environment; such as the human and physical dynamics of the space (Holloway 2014). Previous playground observations (Colabianchi et al. 2011) have found that increasing the amount of play features on a playground can increase the usage rate of these areas by 5 to 7%, per added feature for males and females, respectively. Colabianchi et al. (2011) observed 20 recently refurbished urban school playgrounds and predicted that an increase of 10 items to a playground would increase usage by 50% and 70% in males and females, respectively. Furthermore, there is a growing amount of support for the use of the Primary Physical Education and Sports Premium (PPESP) to enhance children's play and activity by making changes to the outdoor environment (Youth Sport Trust 2018; DfE 2019).

The DfE provides the PPESP to eligible primary schools with the aim of enhancing the health and well-being of pupils. Recently the way in which schools are required to use their funding has changed due to an over-use of funds to employ external sports coaches to deliver their PE provision (Griggs 2016). One of the five key indicators aligned to the aim to support the engagement of all pupils in regular physical activity is *'encouraging active play during break-times and lunchtimes'* (DfE 2019). It is not then surprising that many playground designers, and providers of school playground equipment now actively promote the PPESP funding through their websites. However, as suggested in the DfE (2006) guide, *'schools for the future: designing school grounds'*, the valuable insight from the children and staff at the school should not be overlooked when designing successful and sustainable outdoor play spaces.

However, many fail to consider the 'otherness' of childhood (Jones 2008) when trying to understand children's engagement with break and lunch-times, and in the design and development of a playground environment children will enjoy. The idea of childhood as 'other' from adulthood suggests profound differences in their becoming (Jones 2008). When adults revisit their own childhood experiences they are 'filtered' by the experiences they have had since their adult becoming (Jones 2008). This is not to say these experiences are wholly irrelevant but they cannot be straightforwardly applied or transferred to children lives today. As previous researchers have suggested (Kellett 2005; Jones 2008), children operate with a different, more flexible and unfiltered negotiation of their world. Previous well-intentioned methods of increasing physical activity in children has perpetuated a "controlling and oppressive way" (Matthews 2005) of coercing children to engage in physical activities.

Chapter 5 highlights children have different ideas and views of their environment than adults. Despite this, children's play and physical activity behaviour is regularly controlled and colonised by adults to suit an adultist ideology of childhood and rarely involves input from children (Snow, Bundy, Tranter et al. 2019). Many of the studies from the review in chapter 3 experienced positive effects from an adult prescribed and delivered FMS intervention. However, there were few studies that considered the longevity of the intervention effects, with many studies failing to conduct a follow up. It is a common occurrence for research study participants to revert to a previous behaviour (Thomson 2007; Ridgers et al. 2010), as observed in the studies from chapter 3 which did conduct a follow up. It is likely that previous studies have seen the reversal of positive intervention effects simply due to children reverting to their preferred activities once the adult researchers and their restrictive agenda have left the children's space.

Therefore, this study aims to develop a deeper understanding of user's (children and supervising staff) perception of the current playground environment and explore some of the reasons why children engage, like and dislike specific areas of the playground. Furthermore, child and staff perceptions on the barriers and facilitators to a physically active break-time will be investigated to explore the current, if any, adult constrictions on playground use.

6.2 Methods

The Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist (Tong, Sainsbury, Craig 2007) was used to ensure accurate reporting and to provide a transparency of methods that follow (Thomas and Harden 2008).

6.2.1 Research team and facilitator characteristics

The data collection activities (focus groups and interviews) were facilitated by a male university graduate tutor (MG) (final year PhD student; 36 years old) and a female university Senior Lecturer (AI) with a PhD in children's physical activity (32 years old). These members of the research team had previous training and experience of working with primary school aged children in a both a prescriptive (teaching and coaching) and facilitative role (research activity). Furthermore, both had experience and training in qualitative data collection methods used in this study. Data collection and thematic data analysis were completed by MG and AI using investigator triangulation, whereby any disagreements in interpretation of data outputs were discussed and agreed prior to continuation.

6.2.2 Recruitment

Following ethical approval from the School of Health and Life Sciences ethics committee at Teesside University (Application Number: **250/18**; Appendix G) five schools from the Tees Valley in the North East of England were contacted via email and provided with details for the study. Schools were selected using the list of local schools (www.gov.uk) and were initially chosen for convenience of location and their urban setting. Schools were eligible to take part if they had a minimum of one year five and one year six class. Schools which matched this criteria were then contacted with details of the study. Four schools returned expressions of interest and were contacted further to discuss the project requirements and complete the school management consent forms. Head teachers from three schools (Table 6.1) (including the case study school from chapter 4) returned managerial consent and agreed to act as gatekeepers, identifying and providing study information sheets to eligible participants. Study information and the relevant consent forms were provided for eligible staff, parents of eligible pupils and pupils themselves (assent forms). Staff consent and pupil assent were completed immediately prior to data collection.

Table 6.1. School demographics

	Children on record (n)	Female/male (%)	No. of focus groups per school	Children in receipt of free school meals (%)
School A	565	51 / 49	2	47
School B	520	49 / 51	3	49
School C	303	52 / 48	4	68

6.2.3 Participants

School staff that were in an active role within the playground or in physical activity promotion within the school (PE specialist, health leads, heads and assistant heads, school classroom teachers, playground supervisors and school sports coaches) were eligible to take part. Children from years five and six (9 to 11 years old) were eligible to take part. This study was limited to this age range due to time restrictions and for effective management of the project. Furthermore, the focus group activities planned (drawing, mapping, reading and writing) were beyond the literacy and comprehension level of the younger primary school children. The focus group activities were conducted over the course of one school term (October 2019). Staff were given the option of participating in a semi-structured interview or completing the questions in their own time and sending their completed responses via email.

Table 6.2 Number of staff and children recruited

	Male	Female	Total (n)
Staff (n)	N/A	N/A	11
Pupils (n)	31	34	65

Abbreviations: N/A = not available.

6.2.4 Data collection methods

6.2.4a Methodological rigour

This section describes the methods used during data collection to ensure credibility, dependability, confirmability and transferability (Forero, Nahidi, De Costa et al. 2018). To ensure credibility and dependability of the findings, MG and AI conducted all focus groups in all schools, and maintained an audit trail of all data collection and transcription processes. Focus group activities were discussed prior to visiting the first school to ensure that sufficient time was made available to complete the activities without rushing children to complete tasks and risking low 'reliability' in the outputs. Both facilitators had the required knowledge, training and experience to perform their roles effectively and researcher notes were compared and collated in a post focus group 'debriefing'. Confirmability; the confidence the findings would be corroborated by other researchers (Forero et al. 2018), was assured by investigator and methodological triangulation techniques such as the use of two facilitator outputs and digital recordings to collect data from a variety of data collection methods (see section 6.2.4c). Finally, the degree to which the findings of this study can be generalized to other contexts (transferability) was ensured by a combination of purposive sampling and data saturation (Forero et al. 2018). The child focus group activities that follow, add further confidence to the methodological rigour by ensuring the children were able to freely provide rich and detailed responses that were not influenced by any subconscious pre-conceptions the facilitators may have had.

6.2.4b Child focus groups

Conducting focus groups with children is an effective way of gathering opinions and experiences (Agar, MacDonald, Basch et al. 2005). At the start of each focus group, children were welcomed and introduced to the focus group facilitators and read the summary of the information previously provided to them. School staff were not present during the child activities as it was felt that the presence of these authoritative figures might have affected the honesty in responses. Children were given time at the start of the session for any questions and for them to find out a little bit more about the focus group facilitators, to relax any anxieties they may have had. Children were then asked to clarify the reason they were taking part in the focus groups to ensure everyone understood the purpose of the activity. To be confident in successful data collection and provide a positive experience for the children (Gibson 2007) we limited group size to eight children (Agar et al. 2005) and utilised a number of data collection exercises and activities. A variety of data collection techniques, such as visual prompts, drawing and a ‘secret box’ (described in more detail later) can spark children’s interest and maintain concentration (Punch 2002; Gibson 2007) whilst providing opportunities for children to more effectively engage with the task (Punch 2002). The inclusion of said activities can help initiate further discussion and encourage children to work together to develop their points (Hennessy and Heary 2005).

The focus group discussions were designed to last for a maximum of 60 minutes, as recommended by previous research on the topic (Agar et al. 2005; Gibson 2007) and were conducted in a segregated, quiet, informal space within their familiar school environment (Agar et al. 2005). Room size, room location, seating arrangements and facilitator positioning were considered prior to commencement to ensure maximum comfort, minimal distraction and a non-authoritarian climate (Gibson 2007). The rooms used in each school were an adequate size to accommodate eight children and two facilitators with space for the planned activities but not too large that the children would get distracted. Rooms were located close to toilet and refreshment facilities. Children entered the focus group setting and were asked to gather around the tables and take a seat if they wished. The room was designed so that the groups were naturally split into two smaller groups of four and giving the freedom of choice for children to sit/stand with the children they associated with best. Blank pieces of paper and a surplus of pens were provided to each group to accommodate any anxiety related ‘fiddling’ (Morgan, Gibbs, Maxwell and Britten 2002). These methods were used to maximise interactions among the participants and augment focus group output by allowing a more natural environment for the children (Dilorio, Hockenberry-Eaton, Maibach and Rivero 1994) and to provide relief from any anxiety as a result of the experience (Morgan et al. 2002).

As mentioned previously the facilitators were familiar with working with children and had experience of conducting focus groups that promote an atmosphere where children can feel free to discuss their opinions. However, there were a few occasions where the children in the groups sought confirmation of anonymity; *“will my teacher see this*?” This highlighted the power imbalance between adults and children within this setting and reinforced the importance of the facilitator positioning within this group (Agar et al. 2005; Gibson 2007). Reinforcing the anonymous nature of their responses and explaining that the role of the facilitators in this activity was to listen to their experiences and stories and not to judge or discipline the children (Agar et al. 2005) served two purposes. Firstly, it removed the anxiety of ‘getting into trouble’ for speaking openly, maximising interaction and honesty. Secondly, it removed the inherent power imbalance between adults and children with the facilitator from this point on being perceived by the children as part of the group, rather than as a traditional authoritative figure such as a teacher. Moreover, this shift in power was supported by the use of first names and facilitators seated with the children (Agar et al. 2005) to allow them to more easily identify with the adults in the room and for a more natural interaction.

All focus group discussions were digitally recorded using audio devices. Noticeable changes in body language or persistently repeated opinions were recorded in the facilitator notes to aid in transcription, to support the outputs from the variety of focus group activities and to ensure accuracy of the adult perception of the child's experience/response. Children were told about the devices at the start of the sessions and reminded about the anonymity of responses and that the device served the sole purpose of recording their responses and only the researchers would hear their recordings. During transcription, individual responses were coded by participant number only (e.g., pupil 1, pupil 2 etc.) through the recognition of a change of voice. No other identifiable data was collected. Focus group activities continued until facilitators believed the groups had reached a saturation point, at which point the subsequent activity was introduced. A break was permitted at this period for pupils to use the toilet or simply tell stories that were triggered as result of the previous activity. During this time, focus group activity paperwork was collected and date and time stamped so it could be matched with the audio recording during transcription.

6.2.4c Focus group activities

- *Playground map (visual prompt)*

Mapping techniques and visual prompts have been identified as an innovative and useful way for children to express their views about the use of the spaces they occupy (Agar et al. 2005; Veitch, Salmon and Ball 2008). Children were provided with an A3 sized aerial map of their school playground (Figure 6.1) and given green and red fine tip marker pens. Children were asked to circle areas they liked in green and provide reasons for their enjoyment and explain what about these areas promoted an active break-time. Similarly, red pens were provided to circle the areas they disliked or that prohibited an active break-time and provide reasons for their decisions. Children were encouraged to be creative and draw on the maps if they wished. This activity was designed to gain a wider contextual understanding of the children's perception of the playground environment (Hyndman, Telford, Finch and Benson 2012). It is common for children to differ in their opinion and as a result one area of the playground could be both coloured in green and red pen. The facilitators' role during this task was to seek clarification for ambiguous or seemingly contradictory responses from the children to ensure accuracy of the researcher's perception when transcribing the audio (Agar et al. 2005).

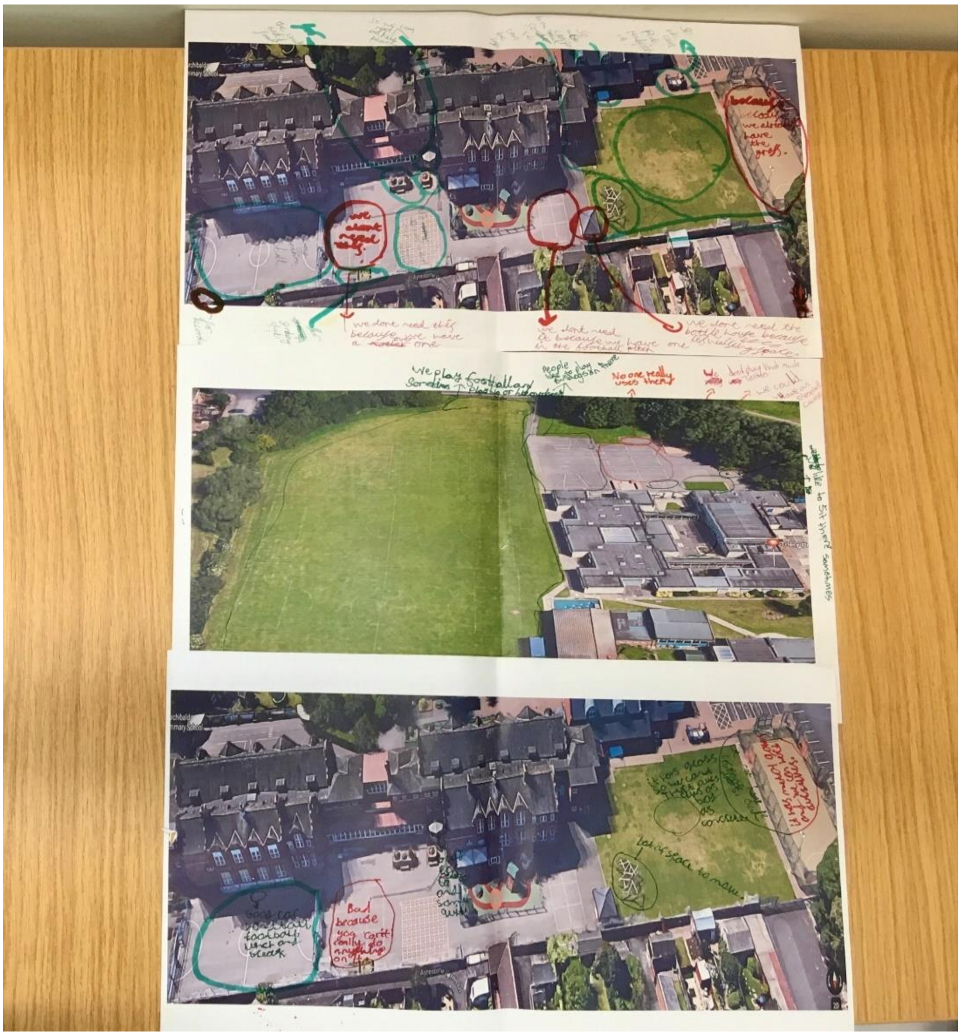


Figure 6.1 Aerial playground mapping activity

Once children had reached a saturation point for this first task, they were then asked to write on sticky notes, the skills they perceived were important to be able to use each of the previously identified areas effectively and place the sticky notes on the correct locations on the map. They were not restricted to the types of skills and had the freedom to choose emotional, social, physical or other skills they perceived as important. The facilitator took a photograph of the map before asking the children to remove the sticky notes and place them in order between a red (hot) and blue (cold) cone, from most important skill to least importance skill, in terms of being able to use the playground effectively (Figure 6.2). The outputs from this task were used to identify any specific skills that children perceived as necessary to be able to be physically active in each of their previously identified playground zones.

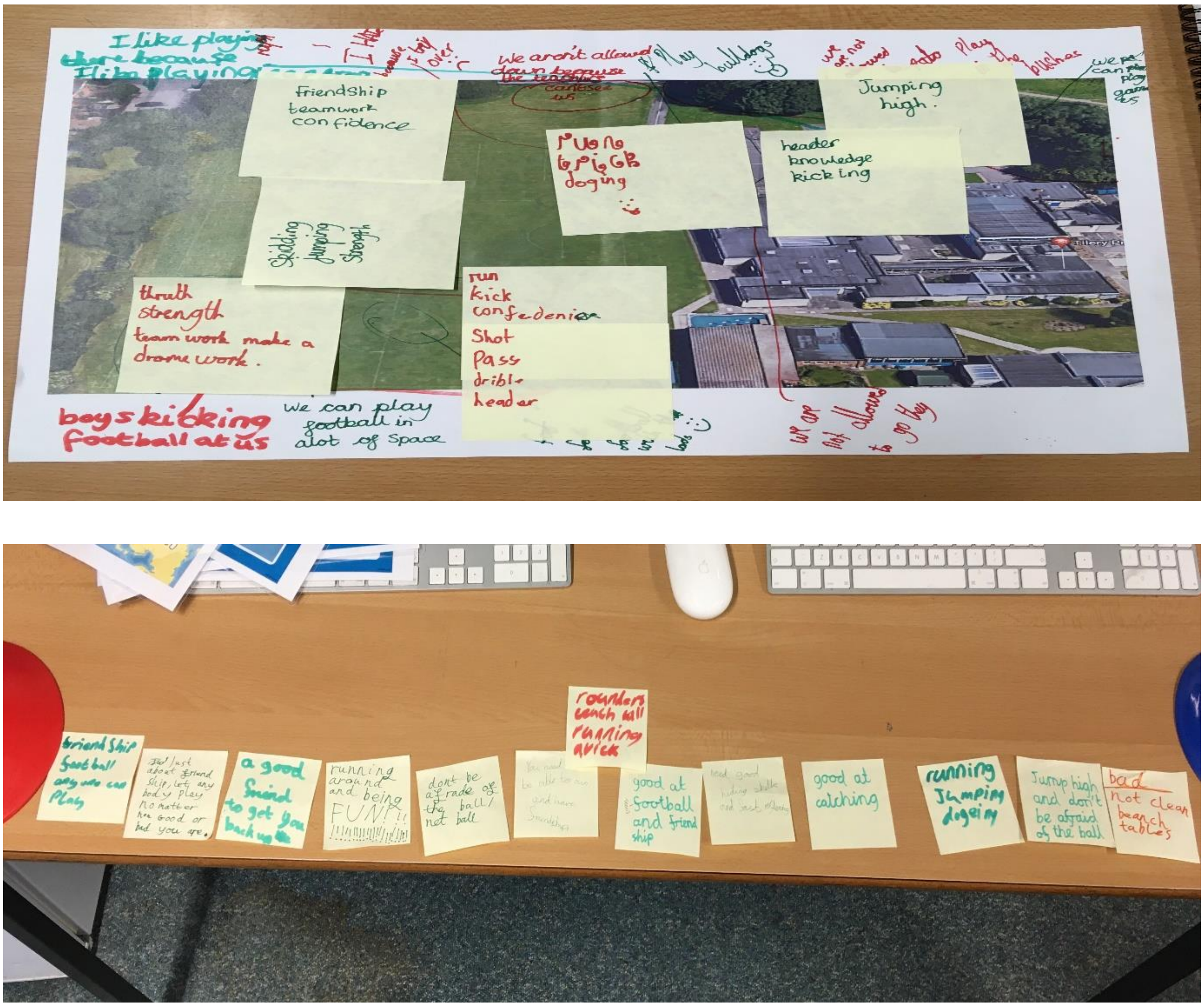


Figure 6.2 Skill requirements of playground areas and order of importance

- *Playground supervisor drawings*

Chapter 4 of this thesis found that the management and supervision of playground activities had a positive effect on the level of MVPA during break-times. However, previous studies have found contrasting results (McKenzie et al. 2010; Caro et al. 2016) suggesting that the roles, actions and behaviours of the staff supervising the playground during break-times and the way in which these roles are perceived by the children can have either positive or negative connotations.

Using creative approaches, such as drawing, can be more effective in interpreting a child's perception of their experiences and emotions (Hill, Laybourn and Borland 1996). Children were given an A4 piece of paper and a selection of pens and pencils and asked to draw the image that came into their head when thinking of a playground supervisor (Figure 6.3). To help them get started with the task children were first asked to write some words down that described their experiences of playground supervisors in their school playgrounds. Drawings and the words children used to describe their playground supervisors were used to stimulate further discussion about what these words meant to them. The discussions were then used to get more accurate interpretations of the outputs during audio transcription.

Figure 6.3 Playground supervisor drawings

- *Playground activities*

Children were asked to design a task/challenge/activity for one area of the playground (Figure 6.4), suggest some rules and instructions and decide on the different skills required to take part in the task. Differentiation for children who excelled in this focus group task were asked to develop their activity further to include instructions and challenges for children of different ability levels (i.e., beginner, achieving and excelling). Children were provided with a challenge card template (previously designed) and a blank piece of A4 paper. It was the child's choice whether to write out their activity on the template provided or use the blank A4 page to draw their activity and write the rules, instructions and description on the reverse. The facilitator's role in this task was to look for clarity in the activities designed and to ensure the children had considered each of the task requirements. Furthermore, facilitators stimulated a deeper discussion on who the children thought should deliver future playground interventions and activities, who they should be predominantly targeted at and who should be in charge of the activities they, themselves had designed.

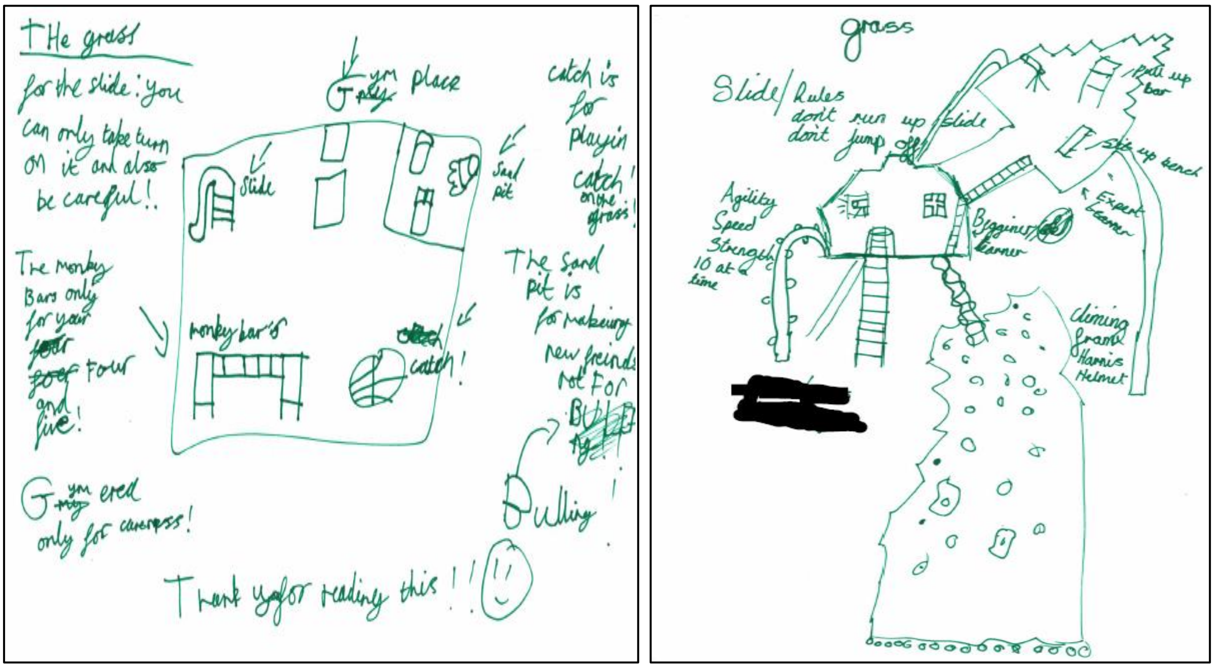


Figure 6.4. Example playground activities

- *'The Magic box'*

The final focus group activity was designed to allow children complete anonymity and remove themselves entirely from the confinement of restrictive adultist opinion. Previous work has suggested a 'secret box' activity removes the fear children have of sharing their thoughts and opinions (Punch 2002). Children were called up one at a time and taken to a private corner of the room to complete their wish (much like a polling station voting booth). Children were given one piece of A5 paper and asked to *"write one wish for the playground that would make it* *better and help you be more active during break-time"*. The children were then asked to fold their piece of paper in to a small square and post it into *'the magic box'*. On completion of their wish they were escorted back to their class by one of the research team so they could not influence the decisions of the remaining children.

6.2.4d Staff data collection

As mentioned previously, staff were first offered a one to one interview to discuss the a priori themes of the project. However, gatekeepers at each of the schools expressed a concern teachers had for allocating time from their day to meet with the researcher. Furthermore, there was concern that senior leaders at the school would be able to identify who had and hadn't taken part in the project. For this reason, staff were given the option of interview or questionnaire. All participating staff chose to complete the questionnaire in their own time and were asked to be as detailed as possible in their responses on the questionnaire, using additional pages if needed. The questionnaire followed the same structure as the children's focus groups with the exclusion of designing playground activities (Appendix H). Staff were asked to return their completed questionnaires via email to myself or place any handwritten copies in a sealed envelope with my name on and leave it with the school reception. Staff were offered the option of providing contact details if they were happy to be contacted further for any responses requiring clarification.

6.2.5 Thematic data handling and analysis

Research themes

A priori themes were formulated using outcomes from the previous chapters in this thesis, previous qualitative research on this topic (Hyndman et al. 2012) and through discussion with a FMS steering group at Teesside University. The steering group consisted of researchers, academics, coaches and sports development officers with an interest and expertise in this research area. The two main themes explored were: 1) The barriers to a physically active playground and 2) The facilitators to a physically active playground. To explore these themes the aforementioned activities were formulated, aimed at provoking data outputs which would predominantly relate to each of the themes.

A number of qualitative analysis methods were considered in the planning stage of this study (ethnography, phenomenology, content analysis, discourse analysis etc.). The decision for the qualitative analysis method employed in this study was driven by the specific pre-existing themes and research question (*barriers* and *facilitators* to a physically active playground during school break-time). Therefore, data collected through the aforementioned activities was subject to a deductive thematic analysis (DTA) in line with Braun and Clarkes' (2006) six stage process. This framework approach allows a more detailed contextual examination of the pre-identified ideas, assumptions, and ideologies underlying these a priori themes (Braun and Clarke 2006) without sacrificing its flexibility to provide "*a rich and detailed, yet complex account of the data*" (Braun and Clarke 2006; pg.5) that is both theoretically and methodologically sound; and can be widely used across a range of epistemologies and research questions (Nowell, Norris, White, Moules 2017).

- *Child focus group data*

The first task for data analysis involved two researchers reading through every focus group activity the children had completed to begin to identify recurring themes across each of the groups (stage 1 - familiarisation with the data). Each activity was then reviewed again and initial features of the data coded in a systematic fashion to collate data relevant to each code (stage 2 – generation of initial codes). Activities were reviewed a third time whilst listening to the associated audio recording from the matched focus group to ensure the children's written points had been interpreted accurately. Audio recordings were not transcribed "verbatim" but were used to ensure that valuable detail relating to the context and the specific nature of the written responses were captured (Rutakumwa, Mugisha, Bernays et al. 2019). Exerts from the audio recordings which matched and supported the focus group activity outputs were transcribed verbatim (by each researcher) and transferred to the table of responses and coded accordingly. As codes were collated, potential themes began to emerge and all relevant codes (and associated data) were transferred under these themes (stage 3 – search for themes). On completion, themes and the associated data items (audio transcriptions and written text) were then reviewed to check for accuracy of interpretation and for any repetition across themes (stage 4 – review of themes).

- *Staff questionnaire*

Completed staff forms were read in full prior to analysis to identify commonality across all responses and to become familiar with the data. Data was then coded and handled following the same processes described above. Responses from the child focus groups and staff responses that did not recur frequently but that had particular resonance due to the language used were grouped under the same code ('valuable insight').

The latent themes that emerged as a result of the aforementioned analysis were grouped under the component titles of the socio-ecological model (SEM); individual, social, physical environment and policy (Davison and Birch 2001) (stage 5 – Definition and names of themes). The multi-level framework that the SEM provides, allows for a constructionist and interpretative examination of the range of socio-cultural factors that can influence physical activity levels during school break-times (Braun and Clarke 2006; Hyndman et al. 2012). This final activity facilitated the creation of the final thematic map (Braun and Clarke 2006) before production of the final interpretive report (stage 6 – production of report).

6.3 Outcomes

A total of 65 children were recruited and provided parental consent and initial assent. At the time of data collection four children were absent and three withdrew assent prior to the start of the focus groups. The remaining 58 children (52% female) participated in focus group activities. There were a total of nine focus groups (number of focus groups per school can be seen in table 6.1). The smallest focus group consisted of six children and the largest focus group consisted of eight children. Children with parental consent were chosen for each focus group by their class teacher (i.e., children in the focus groups were from the same class) and sent to the focus group location. The research staff had no role in selecting children for each focus group so the groups can be considered as selected at random from this perspective.

Eleven members of staff from across the three schools (roles within the school were kept anonymous) returned consent to take part in the study. All of the 11 members of staff who participated chose to send their completed responses via email. Figure 6.5 and 6.6 display the final thematic map for children and staff, respectively. The thematic map is inclusive of the a priori themes (barriers and facilitators), the deductive themes (themes that emerged from the coding) from each of the data collection activities, and their association to each of the SEM components. The magic wish activity was also analysed in respect to the SEM components but did not contribute the themes identified in the thematic map.

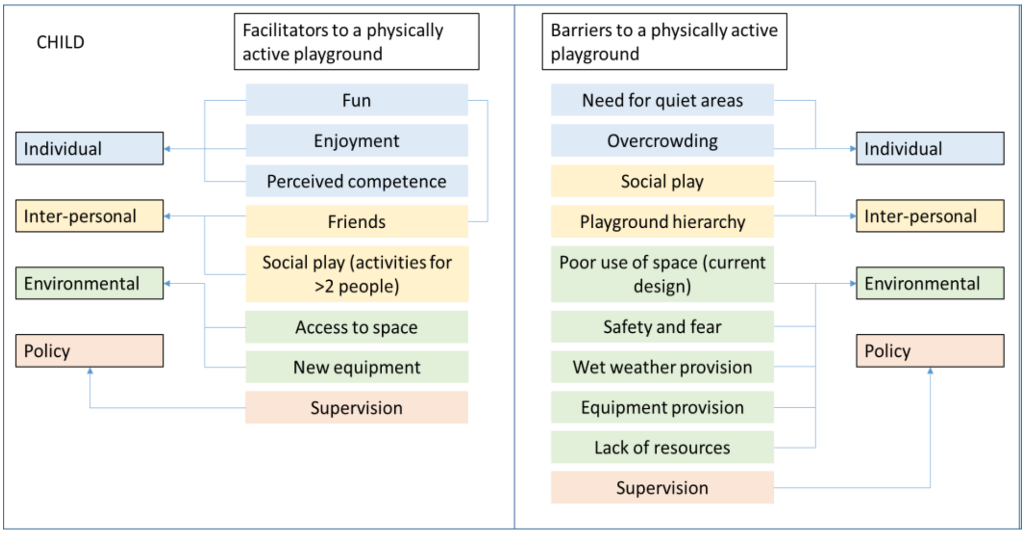


Figure 6.5 Final thematic map showing the SEM barriers and facilitators to a physically active playground from the school children's perspective

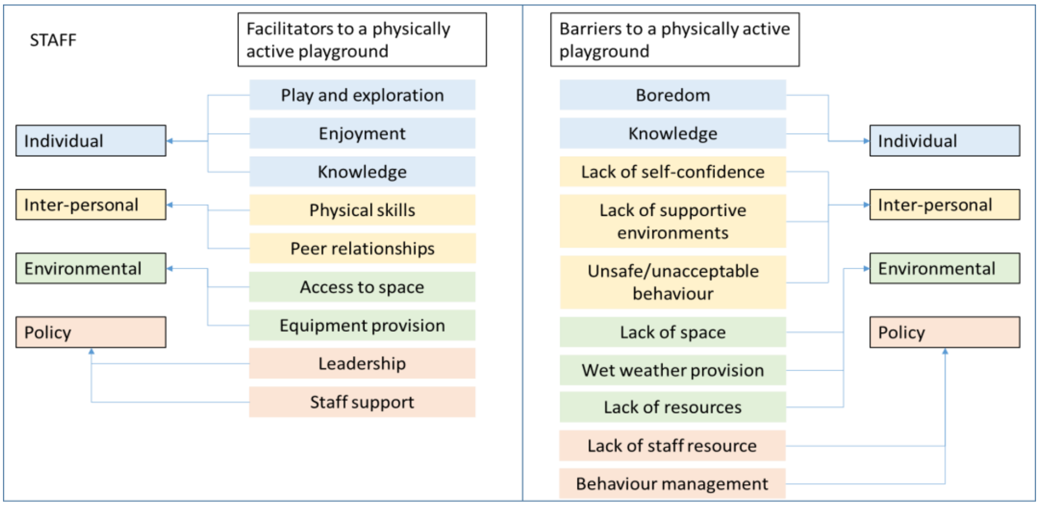


Figure 6.6 Final thematic map showing the SEM barriers and facilitators to a physically active playground from the school staff perspective

A number of themes were identified during analysis that aligned to the individual (fun [child], enjoyment [child and staff], and knowledge of games [staff]), social (peer relationships [staff] and social play [child]), environmental (access to space and equipment provision [child and staff]) and policy (effective supervision [child], and leadership [staff]) levels of the SEM which promoted a physically active break-time. Further, there were SEM themes that prevented a physically active break-time at the individual (overcrowding [child], boredom [staff]), social (playground hierarchy [child], lack of social support [staff]), environmental (poor use of space [child], lack of space [staff], safety [child], equipment provision [child], wet weather provision [staff]), and policy (lack of staff resource [staff], supervision [child]) levels. Understanding how these factors interact and influence physical activity levels of children during school lunch and break-times can be used by policy makers and individuals in positions of seniority (head teachers) when planning school playground provisions (Hyndman et al. 2012) and in the design of playground interventions. These themes are discussed further in the following section (section 6.4 discussion of research findings) in light of theory and research on the social and environmental influences (barriers and facilitators) on children's physical activity engagement during school break and lunch-times.

- *Magic wish (the 'magic box')*

Children's wishes focussed on play, adventure, and fun. Wishes were predominantly concentrated on the provision of new equipment and longer break-times. Staff wishes for the school playground focussed on a wider development of playground structure, policy changes, management and support. Magic wish responses can be seen in Table 6.3. Responses are separated for children and staff and divided into small and large wishes dependent on the resources (physical and monetary) needed or the surface area required (Hyndman et al. 2012). Further, the wishes are separated in to categories based on their desired outcomes (i.e., physical environment, individual/social or policy).

Table 6.3. School children and staff magic wish responses.

		Children	Staff
Physical environment	Small items	• Cargo nets • Monkey bars* and gym equipment • Slides* • Swings* • Seesaw • Tyres • Bikes and scooters* • More equipment* • Make it more fun • To be able to do more things on the tyres • Trampolines* • Something fun – like hunts • Fairer games • Spider net climbing frame	• More scooters and bikes • Be able to use the grass • More equipment* • New fresh games
	Large items	• Obstacle course • VR booth • More options for indoor play* • Climbing wall with buzzers • Running track • A field so we can do rugby • Make a basketball pitch • More playground things (climbing frames, swings, slides, roundabout) • Swimming pool • Big massive slide • Big Bouncy castle	• A school field for summer – for expansive games and to avoid confrontation • New grassy area • A general overhaul of the outside area to make it more inviting and engaging • Another MUGA on the concrete area (less injuries) • More outdoor areas to explore and play • A more interesting environment with a variety of areas to explore and play • More space • A sheltered comfy seating area
Individual and Social		• I wish to make everyone happy on the playground • More exciting games with more people • I would like to be good at gymnastics and flips • Do dangerous stuff	• Self-regulation • Personal power and resilience – to cope with losing and improving at activities/games
Policy		• More options for indoor play* • More time* • Tag rugby coach • Less tolerance to bullies • More timetabled time on the ball-court • To be able to use KS1 playground*	• Training for staff* • Training for playground leaders* and staff • More equipment and training for staff • Involve staff more

*Items occurred multiple times in magic wish responses (multiple = three or more)

6.4 Discussion of research findings

6.4.1 Individual and social factors

Individual level facilitators of physical activity that emerged from the child focus group data focussed predominantly on the intrinsic desires to have fun (*"Because my friends push me on the low swings, it's fun"; "it is fun to try new things"; "me and my friends play games here…the maze game because it is fun"*; *"we play tag, it's very fun")*, for the enjoyment of activities (*"I like it because I get to play football"; "I like playing there because I can play leapfrog"; "I like it cause we can play tennis and get tennis rackets")* and the belief they will do well in a specific activity (perceived competence) (*"…football is a good sport for me"; "…because I likely do well"*).

The desire for physical competence is a major influence on the engagement in play (Snow et al. 2019). Barbour (1999) suggested that the type of activities children take part in are a result of similarities in movement ability and movement skill competency, with children of low physical competence reluctant to approach activities requiring a higher level of ability. This is supported by Snow et al. 2019, who conducted focus group activities on 8 to 10 year old females and found that play was largely affected by the desire to master certain skills needed to engage in play. Evidence suggests that when FMS are taught to younger children (4 to 9 year olds), increases in confidence in their ability results in participation in physical activity during other parts of the day (Parrish, Yeatman, Iverson and Russell 2012). As children age they are more aware of their ability, or lack thereof, and as a result less likely to participate in activities they desire for fear of embarrassment (Parrish et al. 2012; Jones et al. 2020). The desire for actual physical competence in Snow et al. (2019) and the engagement (or disengagement) in specific activities due to perceptions of physical competence in this study are slightly difference concepts. However, the aspirations for and perceptions of competency were driven by the same yearning for a sense of social belonging.

However, children in this study identified that they took part in activities that they *"would likely do well at"* but also participated in activities for social reasons irrespective of any assessment of physical competence and in the absence of a specified activity *("this is where my friends are"; "because most of my friends play here"*; *"because my friends are here…"*). Parrish et al. (2012) focus group findings from children aged 9 to 11 highlighted that children were more likely to take part in games their friends were playing, even if they had a desire to play something else. As part of the current study, children designed their own activities for the playground. During this task the children highlighted the skills needed to take part in their activities, which focussed predominantly on physical ability (speed, strength, power, kicking, catching, fitness, ball control, skipping/jumping). However, social skills (friendship, teamwork) and psychological skills (confidence) also emerged as important pre-requisites to participate in the designed activities. One group of children in this study, when designing activities for their playground highlighted:

> *"let everyone take part and be nice, we don't really care what skills you have we just like letting people play, it's just about friendship"*

Findings from chapter 4 in this thesis suggested that there is more than a simple gender preference operational when children select areas of the playground to "play" in. The influence of physical competence, perceived physical competence and friendship identified here re-enforces this assumption and highlights the potential impact of positive peer relationships and social position as a driver for physical activity engagement and opportunities for FMS development.

During the DTA it was initially difficult to define data items from the children's activities into the separate components of the SEM. This may be partly due to the inherent interaction between each of the components of the SEM (Salmon and King 2010). However, this interaction was particularly evident between the individual and social items in the model. Many of the individual (personal) factors children gave for liking and disliking particular areas were driven largely by the desire for social interaction or social play (social). For example, the individual desire for quiet and relaxation (*"I like it because it's a good place to private talk")* and for playing games (*"me and my friends play games here"* and *"I play tag with my friends"*), were grounded by positive peer relationships.

Similar to previous qualitative studies with children (Pearce and Bailey 2011; Hyndman et al. 2012; Parrish et al. 2012), the conversations with children largely revolved around friendship and interaction with others, suggesting the importance of social relationships in this setting. However, evidence suggests children's social relationships are relatively unstable and influenced by the level of peer acceptance and popularity (Oberle, Schonert-Reichl, and Thomson 2009). Social acceptance by peers is of central importance in children's social functioning, psychological well-being (Oberle, et al. 2009), and better school adjustment (Wentzel, Barry, Caldwell 2004). Simply having friends, however, is a weak predictor of environmental adjustment and rather it is the quality of these friendships and the reciprocation of friendship from peers that holds more importance (Oberle et al. 2009). The desire for children to engage in social games, requiring more than two people could be perceived as a method employed by the children in this study at increasing the 'quality' of their friendships

> *"because we get to run around and play bulldogs", "we sometime get to play football tennis", "we play football and sometimes tig", "we play hide and seek"*.

Furthermore, through participation in activities due to a shared ardour is likely to increase the prospect of developing multiple mutually reciprocated friendships that form into stronger friendship groups. However, the opportunity for social play was also often linked to less desirable playground experiences *("there are too many footballs", "there are a lot of fights and it stops playing", "play is too rough"*) and traditional playground hierarchies (*"the boys take the ball court most of the time", "because other year groups use it", "a lot of fights with year 6's")* which could be considered as barriers to physical activity for individuals who avoid competitive games for fear of conflict and to avoid the hegemonic masculinity of the sporting (predominantly football) culture of the primary school playground (Renold 1997). This point was raised by some of the females in this study who identified some of these hegemonic masculinities displayed during break-times:

> **Pupil 1***: “we don’t like playing here because you get hurt and the boys kick the footballs at you”*
>
> **Pupil 2***: “there is loads of fights”*
>
> **Pupil3***: “No…” (Male)*
>
> **Pupil1***: “YEAH THERE IS”*
>
> **Pupil 2***: “have you seen how many fights happen”*
>
> **Pupil 1***: “there was a fight here”*
>
> **Pupil 3***: “oh yeah there was a fight there the other day” (male)*
>
> **Pupil 3***: “we have fights constantly” (smiling) (male)*
>
> **Pupil 1***: “I hate it”*

One male participant in this group can initially be observed trying to address these statements by perhaps claiming either the absence of fights or trying to explain the reason for fights, before he is interrupted. He then concedes and becomes somewhat proud with a contented claim of *“<u>WE</u> have fights constantly”.* Whether this male actively participates in this behaviour or not, this statement can be perceived as attempt to associate himself to these hegemonic masculine behaviours deemed important for his social status (Renold 1997).

Football has been (Renold 1997) and continues to be (chapter 5 in this Thesis; Thomson 2007; Pearce and Bailey 2011) the predominant activity dominating playground space. Similarly, the schools participating in this study had playgrounds which were monopolised by the established football space (marked and worn out pitches, caged football zones, painted goals and footballs provided). This now, somewhat unconscious, domination of the playground space for football leads to a desperate rush to govern and preside over the remaining playground space when the bell rings for break-time (Thomson 2007). Thomson (2007) observed children claiming possession of playground space by marking areas with their coats and school bags for their activities and any attempt at invasion from others resulted in retaliation and conflict. This issue becomes exacerbated during winter months when access to the play spaces hosting these dominant playground games is prohibited due to wet, icy and muddy conditions directing these activities into the already restricted, fiercely contested areas of the playground.

Similar individual level facilitators were identified from staff outputs with play, exploration and enjoyment identified as key to children's participant in activities.

> *"Children like to climb on the rocks and tyres"; "children often look to play their own games…"; "children like freedom and unstructured play"*; *"children enjoy playing football"; "children enjoy the ball court and playing football"*

Although adults (staff) in this study seem to understand the individual value of play, they identified more frequently with the extrinsic (social) values of peer relationships and social development:

> *"teamwork and collaboration"; "ability to listen to others"; "…take turns and play fair", "need to understand the rules"; "social is important to feel comfortable playing in front of others"*

Previous research exploring children's geographies has highlighted that the intrinsic value of play is not acknowledged by teachers and policy makers (Snow et al. 2019) and that opportunities for play, particularly outdoor play is decreasing with increased emphasis on classroom based, adult organised activities (Saunders, Chaput and Tremblay 2014). Furthermore, adults naturally follow their instincts to colonise children's places and create safe and easy to monitor play spaces which often means the naturally sporadic and exploratory play behaviours of children (Thomson 2007; Mackintosh, Ridley, Stratton, Ridgers 2016) are perceived as hyperactive, disruptive and undesirable and are consequently dealt with 'accordingly' (*"children need to be guided on how to play safely", "children need to be aware they will be punished (equipment removed) for bad behaviour")*[2 See footnote].

With that said, staff perception of the need for educating on how to play and how to use equipment (*"having a good knowledge of playground games…"; "Showing children how to play more imaginatively would help them be more active"; "children need to be taught games and skills before using equipment"; "children are not interested in the activities and play their own games"; "knowledge on games and how the equipment can be used"; "children don't know how to play imaginative games")* is somewhat supported by children's own acknowledgement of a lack of things to do, despite the availability of large open spaces (*"it is just kind of a massive plain field but with nothing to do on it"; "…there is all that space to do basically nothing"*). However, the framework of rules and regulations and their sometimes militant surveillance constricts children's impromptu acquisition of knowledge, limits their motivation and confidence in the playground environment; and delays their development of physical literacy (Thomson 2007).

The staff opinions on the 'correct' use of the playground could be interpreted from a dualist perspective, whereby there is either a right or wrong way of 'playing'. Although one cannot argue that children will benefit from *"teamwork and collaboration"* and an *"ability to listen to others"* throughout their child, adolescent and indeed adult becoming; the adult regulation and enforcement of these qualities goes against the nurturing concept of physical literacy. Children develop a natural, more flexible interaction with the environments that surround them and can be very creative and innovative when adapting architectural features of the playground such

[2] During a visit to one school for data collection I observed an adult member of staff on the playground screaming at a child to bring her the ball. The teacher confiscated the ball and continued chastising the child. Although I am aware that the previous unobserved context is important, what I had observed was the child run across the playground chasing their friend. There was a ball in the child's path so he kicked it against a perimeter wall. The perimeter wall had flower beds around its border which the ball landed in….this is what seemed to upset the adult member of staff. My question and suppose concern here is Who's space is this? And at what point did having a nice flower display take precedent over the children's enjoyment and desire to play.

as bins, bollards, fencing, walls etc. (Thomson 2007). Objects in the environment are not inanimate features to which we ascribe an abstract concept but are meaningful in a sense that they ‘engage’ with us, indicating how we can interact effectively with them (Whitehead 2007). Children in this study identified areas of the playground that to the researcher looked like baron waste land, however, children circled these areas for the inanimate objects (bollards, rocks) that existed there (for example, *“I like playing here cause I can play leapfrog”*). However, these behaviours are often stifled by staff on the playground perceiving their use as inappropriate, unsafe (*“children given free choice often decide on inappropriate games”; “children need to follow the rules and understand what they can and can’t do”*) and because they do not fit in with their framework of rules. Jones (2008) suggested adult constrictions, desires and agenda restrict children’s lives and their practices when discovering their identity in a changing environment.

Children learn very early on the notion of rule keeping and are generally faced with a daily list of ‘don’ts’ before entering their play space (Thomson 2007). Crease (2002) explains that infants go through a number of stages in their becoming, described as first ‘I move’, then ‘I can’, and finally ‘I can do’. A large proportion of children in this study were faced with physical barriers, boundaries and rules which reduced their freedom to ‘move’ and therefore unable to explore the ‘I can’ and subsequently the ‘I can do…’

6.4.2 Physical environment and policy level

As previously mentioned, the large open spaces identified in this study were predominantly grass fields and expansive concrete areas that often flood in wet weather leading to prohibited access due to adverse conditions. The data from the children and staff suggest that this is an issue that needs addressing at policy level with adequate investment in facilities for all weathers:

Children

> *"sometimes not allowed here when it is wet or muddy", "can't use it when it is full of snow", "not allowed in when it is snowing", "we are not allowed on the grass when it is wet", "we are not allowed on when it is icy or snowy cause we might fall over and get hurt", "when it rains there are puddles for weeks"*

Staff

> *"space is a problem when the grass is wet, children are confined to the hard area which prevents children playing"; "bad weather prevents physical activity at break times"; "not being able to use the field when it is wet has a negative impact as children are not allowed footballs on these days", "rock area is dangerous when it is wet"*

As one child said "*if it is raining, why not put a roof on the MUGA"* (year 6 male). Similar findings from Australian children, also recognised the need for 'weather protection' (Hyndman and Telford 2015), demonstrating that despite very different weather conditions, the play restrictions being enforced on children in primary school playgrounds is an issue experienced internationally.

The appearance of staff members on the playground acting like shepherds tending their disobedient flock may be driven more by the inadequate investment at a policy level in the children's physical, social and emotional development during this important period in a child's day (Baines and Blatchford 2019b). This was further highlighted by a number of staff members who identified a lack of staff resources prevented them from engaging in anything other than crowd control (*"there is lots of activity and a lot to monitor for just two members of staff", "not enough staff being able to supervise and keep children safe", "staff are limited, we already have some staff on the playground but not all the time and they can't cover everywhere"; staff are occupied dealing with behaviour so seldom able to engage with activities"*). This is in contrast to self-report findings from national (UK) school surveys from 1995 to 2017 which identified that there are now more adults supervising than there has been in the previous twenty-two years (Baines and Blatchford 2019b). Although these numbers are likely school dependent, the actions of the supervisors may be more important than the numbers available. Children highlighted the potential for teachers to act as facilitators ("*some teachers won't come out but 'Miss D' played like Mr Fox or something with us before but not many (teacher) do")* but are too often restricted by the number of staff available (*"sometimes there is only one member of staff on duty so we have to stay where the teacher can see them so they are safe and don't get hurt"; "….but I do get it cause there are only like two dinner nannies"; "that's the part we are not allowed down, well we are sometimes but not all days when we don't have teachers, because when it (the bank) goes down the teachers can't see us"*).

In contrast, inadequate staffing resources may not always be the issue as there were staff members who believed there was little else that could, or should be done *("we already use a football pitch, skipping and a large 100 square – there are plenty of activities during break-time which encourage children to play"*). Moreover, when asked 'what do you think the role of the playground supervisor is and what do you think the effect of their presence has on physical activity levels?' one male member of staff responded simply with:

"On a break time there is already enough adults supervising"

Whether this response was to prevent me suggesting an increase in supervision or a misinterpretation of the question asked, it nonetheless represents a distinct lack of time and thought invested in a response to this issue. This fact when paired with the tendency of participating staff to be vague on this response leads one to infer an overall disinterest in the children's well-being during this time. Therefore the function of break-time in this school may be as Baines and Blatchford (2019) infer, *"an unimportant pause in an otherwise busy day".* This becomes more problematic when considering that school staff perceive lack of supportive relationships outside of school as a barrier to children's physical activity levels (*"parents are not supportive and do not encourage an active lifestyle"*).

As mentioned earlier, the UK government offers eligible primary school's with a PPESP to provide a minimum of 30 minutes of physical activity per day for all pupils (DfE 2019). Children spend a large amount of their waking hours in the school environment (Fox et al. 2004; Dobbins et al. 2013) making it one setting which, with effective use of the PPESP, could substantially contribute to children's daily physical activity levels. All schools in receipt of the funding are required to provide information on their school websites about how they intend to invest the funding to improve the health and well-being of every child. A list of how the three schools included in this study intended on spending their 2018/19 premium is below:

- improve the PE and sports provision through staff training and access to specialist sports teachers and coaches;
- purchase resources to support and enhance the delivery PE and sports;
- provide opportunities for pupils to participate in intra and inter schools competitions through Local Sports Partnership
- Provide transport to and from sporting events and festivals with local sporting heroes
- Equipment/resources/materials
- After school clubs

Only one school mentioned lunchtimes as part of an aim to achieve 30 minutes of physical activity per day:

- Structured lunchtimes with a sports coach, lunch supervisors and pupil leaders targeting inactive children during lunch

However, the structured sessions mentioned from this school were perceived by the children as PE lessons which took place on the MUGA (*"sometimes you play football on it (the grass) when classes are using the MUGA for PE during lunch times").* As mentioned previously, use of the grass is prohibited in wet weather and there is already a lack of alternative space.

Furthermore, lunchtimes are a period in the child's day when they should be free to choose the activities they engage in (Mulryan-Kyne 2014), and break-times should move away from delivering curricular PE and being 'educated' to a period in the day with the primary goal of enabling every child to become physically literate (Whitehead 2007). Moreover, although this one school's acknowledgement of break-times as a period of time that would benefit from investment, the plans and ideas mentioned previously were alongside the provision for the daily mile, access to new sports and activities and a lunchtime wake up dance activity – all of which was allocated a combined £750 from the £19,520 PPESP allocated to this school.

All three school's mentioned the intention to secure resources to support and enhance the delivery of PE, the promotion of sport and the provision of equipment, resources and materials. However, it is clear from the children's *("there are no activities", "we need some more equipment", "nothing to do", "we need some basketball hoops"*, *"we could play tag rugby….have an expert to teach us", "we can't play it (basketball) there cause there are no hoops…*") and staff responses (*"having more equipment would help children be more active", "there is a lack of equipment"*) that this provision of equipment has not been invested on the playground. The belief that providing non-fixed playground equipment would enhance physical activity levels is not isolated to the schools included in this study. Parrish et al. (2012) found both staff and children believed that provision of non-fixed equipment and playground markings can increase physical activity levels in children who enjoy both group and solitary play. Furthermore, reviews on playground activity levels have also found positive effects of the provision of playground equipment and markings (Ridgers et al. 2006; Escalante et al. 2013).

Whilst the physical activity levels of children during break-times is much more complex (Ridgers et al. 2006) the lack of valuable and sustainable investment from all three schools in their playground provision is worrying and in contrast to the recommendations provided by the DfE (2019). A continuation in the marginalisation of break-times for more curricular focussed adult led activities (i.e., PE); alongside a reduction in time provided for break-times (Baines and Blatchford 2019) and inadequate investment in the primary school playground provision, will lead to further reductions in exploratory play and reduced opportunity to develop physical literacy. Furthermore, without recognition of the importance of break-times in children's physical, social and emotional development and the provision of a sustainable intervention, the current playground behaviours will continue to re-enforce the adult-child power distribution (Jones 2008).

6.4.3 Perception of playground staff and their roles

The active interest of the adult members of staff in the school were explored during the playground supervisor and playground activities tasks. The excerpt below highlights the general theme emerging related to children's perception of staff involvement during current and future playground activities:

> **Facilitator**: "who would you like to deliver the activities? Who should be in charge?"
>
> **Pupil 1**: *"you guys"*
>
> **Facilitator**: "why?"
>
> **Pupil 2**: *"you guys because you are fun and funny"*
>
> **Facilitator**: "we're funny?"
>
> **Pupil 3**: *"Jack and Lewis are funny too, they make up games and they turn out to be really fun"* (Jack and Lewis are external coaches)
>
> **Pupil 1**: *"I should have picked them"*
>
> **Facilitator**: Does anyone think the teachers should be more involved?
>
> **Pupil 1**: *"teachers are annoying and they are not sporty"*
>
> **Pupil 2**: *"there are only two teachers who are sporty"*

Pupil 3: *"they are not sporty at all and they are all girls"*

Facilitator: "so can we go a bit further with this, if I say, we've come up with all these new fun activities and the teachers are going to help deliver them, what would you say? What will happen?"

Pupil 3: *"they are probably not going to do it"*

Facilitator: "how come?"

Pupil 1: *"they normally stand around and like look around with their hands on their hips"*

Pupil 2: *"no they don't, you are making our teachers sound bad"*

Evidence suggests there is a need to provide children with access to a supportive, social environment (Parrish et al. 2012; Hyndman and Telford 2015). Children at participating schools had a mix of teachers, teaching assistants, 'dinner nannies' and 'playground friends' that helped monitor the playground during break-times. Children highlighted they would like their teachers to be more involved during break-time but highlighted they wanted teachers based on 'sportiness' (*"…because they are good at sport", "teachers are not that sporty", "Mr T and Mr L are the sportiest but there are no more sporty ones", "our teachers are not that sporty, there is only like three and they are not that sporty").*

One worrying output from the focus groups highlighted that some playground staff had a dislike for them ("*Mrs X hates us, doesn't Mrs X hate us?...and she makes fun of us….she tries to be funny and make up nicknames but they are not funny"*). The variety of views relating to the role that the primary school playground has in promoting play and physical activity presented in this study suggest very different ideas between the value that children, staff and schools as a whole place on this period in the day. Although in the current study we were unable to distinguish between staff positions within the school (head teacher, teacher, teaching assistant etc.) due to the anonymous nature of the staff responses; previous research has found that head teachers from different schools have very different ideas about the value and role of break-time (Baines and Blatchford 2019a) and therefore, the behaviours, actions and opinions of the staff (from staff and child perspectives) in the current study are likely a result of (or lack of) the agenda at senior management levels.

Overall, staff perceived their role as a combination of encouraging a supportive and safe environment *("supervisors should be at their station, organising resources and facilitating", "adult presence ensures that children feel safe and are used for advice and support if needed"*) and promoting engagement in physical activity *("my role is to keep children safe and happy and to encourage some children to be active"*). However, inadequacies in resource provision (number of staff and workload time) mentioned previously result in the perception from children that the solitary role of playground staff is for safety and enforcement of rules and boundaries (*"sometimes we do use here for bulldogs, but the younger ones are doing it now so we are not allowed", "if we go on there the teachers can't see us and we'll get dirty", "dinner nannies say we can only play with your own year group…it's so annoying…", "they look after us, stop fighting and help people who are hurt"*).

Children will inevitably, unless monitored/supervised to some degree, experience undesirable consequences (e.g., bullying, injuries) as the result of a non-regulated playground environment. However, the issue of bullying was only mentioned twice in this study (by children) suggesting that this issue is currently effectively managed in the participating schools. The safeguarding of children should be done at a policy level, ensuring adequate provision is put in place to reduce negative playground experiences. However, staff in charge of supervising play at break-times are taking a more interventionist approach towards the management of the playground, with the result that children's play at school is becoming a rationalised activity (Thomson 2014). Despite this harmful adult management emerging from a well-intentioned concern for child safety and quality playground experiences, it more frequently result in children internalising these same behaviours and therefore regulate their own actions and exploration of the playground environment in a similar way (Thomson 2007;

Hyndman and Telford 2015). Thomson (2007) raises this concern after observing how the children's list of rules often grows over time without additional input from school staff. This highlights how children perpetuate a culture of discipline and order, becoming embodied within regulation of rule-bound play within and outside of school (Thomson 2007).

Adults, although full of good intentions, cannot know the world of children (Thomson 2007; Jones 2008). However, we do have a responsibility to promote, encourage and co-design play spaces for children, or otherwise face a playground full of *"big massive slides", "big bouncy castles", "…dangerous stuff"* and *"swimming pools"* (Table 6.3). From the variety of staff and child accounts provided in this study and in previous studies (Thomson 2007) on the level and role of staff interaction during break-times it seems that, beyond child safety, there is no standardised, universally accepted requirement or behaviour of playground staff in the primary school setting. This allows for a large variation in the day to day management of the school playground, dependent largely upon the member of staff who happens to be 'on duty' that day (mood, personality, personal agenda, etc.). When asked about the staff who were present on their playgrounds during break and lunch-times, this is just a sample of the words the children used to describe them:

> *Safe; loving; try to keep us safe from bully's; caring; angry; helping; laughable; sharing; bossy; hardworking; respectful; kind; mad; safety; hate.*

Although mostly positive, the variety of qualities cited by the children gives an idea of the variety of adult personas that occupy children's playgrounds during break-times. As previously mentioned, children internalise and embody the behaviours of the individuals who monitor the playground (Thomson 2007). It is therefore important that these individuals understand the importance of their behaviours and the positive influence they can have on the social and physical activity behaviours of the children who occupy the playground space.

6.4.4 Safety and fear (and awareness of legislation/legal issues)

The school playground offers opportunities for children to be socially and physically active. However, many have raised concerns over the safety management and injury occurrence (Howard, MacArthur, Willan et al. 2005; Salminen, Kurenniemi, Raback et al. 2014; Olsen and Kennedy 2019) and the effect this has on children's physical activity levels (Hyndman and Telford 2015). Hyndman and Telford (2015) highlighted a number of perceived safety (maintenance of equipment) and safety management (staff responsibilities and behaviour) concerns that prevented children from engaging in physical activity during break-times. Similarly, children in this study expressed concern for a number of built and natural safety issues which prevented them playing in some areas and therefore acted as barriers to physical activity. Barriers to physical activity which occur as a consequence of the natural environment (tree locations, naturally undulating surfaces) may be hard to manage and overcome. However, natural and man-made barriers as a result of inadequate maintenance justify more effective observation and management in order to explore solutions that remove/reduce the barriers to physical activity. Below are examples of some of these natural and man-made barriers:

- *"I'm circling the bushes, I don't like the bushes, you get nettled and that";*
- *"I don't like because there are rocks, there have been legs and heads broken";*
- *"People fling glass and that in there";*
- *"It (the grass) is too long, you can kick a football as hard as you want and it goes like one inch. The man's like thingy'ed it (mowed) like five times and it is still long";*
- "*Need to block the hole, it's got sharp edges, once someone shredded their coat";*
- *"We don't play here because of the bushes. We play football tennis or tennis but when you kick the ball or whack it, then it goes in the bushes and we can't find it"*

Playground surfaces were perceived as both a barrier and facilitator to physical activity dependent on surface type. Grass and synthetic (AstroTurf) surfaces were perceived as a safer surface and encouraged physical activity *("it has grass so we can trust ourselves, not like concrete"; "we should put the same surface down as the MUGA"; "I like to play in this area because it is soft when you fall over")* whilst concrete and the sand added to the synthetic surfaces were perceived as barriers to physical activity *("can I just say…if you fall on this, its stone and it really hurts, "there is sand! When people fall over it hurts more", "because I don't like the pavement and I always trip over"*). However, it should be noted that the majority of opportunities for climbing type activities in the participating school playgrounds were on suitable impact absorbing surfaces (BS EN 11777) and the issues children raised relating to surface preference were from fear of injury from ground level falls (trips and slips). The royal society for the prevention of accidents (ROSPA 2019) state that injuries to children on playgrounds are inevitable and the functions of children's play is about exploring the environment, the objects in it and the child's own body and mind. 'Wrapping the school playground in cotton wool' only serves to reduce children's opportunities to be active (Hyndman and Telford 2015). Furthermore, suggestions of resurfacing and sizeable changes to the physical structures of the playground are beyond this studies position.

We live in an era of legislative fear. According to ROSPA (2019) school managers have a moral and legal responsibility for the care and maintenance of the environment, inclusive of the playground. Acts of parliament (Occupiers' Liability Acts 1984; Health and Safety at Work Act 1974; The Management of Health and Safety at Work Regulations 1999) and British and European standards for playground equipment and surfacing (BS EN1176/1177) exist as guidelines to support playground managers in the correct design and maintenance of children's playgrounds. However, it is clear that the awareness of the potential for legal action as a result of improper playground management and supervision plays an active role in the culture of primary school playgrounds. The excerpt below is an example of how the concerns of teachers, senior school leaders and parents filter down and become embodied in children's conscious thought:

Pupil 1: *"what's the parkour course?"*

Facilitator: "that's what he is going to design now"

Pupil 1: *"what if you fall and break your neck?"*

Pupil 2: *"we would teach people how to do thing like Spiderman, running up walls and do backflips"*

Pupil 3: *"No backflips cause I would say a backflip on a trampoline it's like…."* (Interrupted)

Pupil 2: *"you might land on your neck"*

Pupil 3: *"yeah and front flips are actually easier than backflips"*

Pupil 1: *"no, no, no, but still what about if someone gets seriously injured then it is the **schools fault**, remember the trampolines are in the floor not with walls, so flip, flip off the trampoline and bang your head"*

Facilitator: *"so if there are some things in this area that would need to change to make it safer what would they be? What could you change or add in to make it safer?*

Pupil 3: *"we could put mats around all of it, and where the springs are, so if someone falls it is not going to be as bad if it is softer"*

Pupil 2: *"we could have harnesses for the trampolines and the parkour for higher things"*

The responses from the children in this focus group show an evolved mind-set and resourcefulness whilst working within the constraints of an adultist agenda. However, the issue of blame and accountability are very much adult issues and again highlight the subliminal presence of the adult on the playground and in the planning of playground activities, in the absence of any physical adult presence.

6.5 Summary and conclusion

This study aimed to expand on the findings from chapter 4 and chapter 5 by exploring school children's and school staff perception of the current school playground and identify reasons for enjoyment, engagement and dissociation with specific playground areas based around the SEM framework. Furthermore, focus group activities and questionnaires were created with the aim of exploring playground user's perceptions on how the playground is currently used to promote, or prevent a physically active break-time. There have been limited studies exploring the SEM components within a school context (Hyndman et al. 2012). To our knowledge this is the first use of the SEM framework to qualitatively explore the complex contexts presented to UK primary school children during their 'free play' time.

This qualitative evaluation has identified differences between the adult and child perception of the primary school playground. These differences affirm the need to actively include children in future playground planning. Many schools ask their pupils *'what should we do?'* Or *'what would you like on the playground?'* However, for most, this is where this partnership ends. This does not go unnoticed by the children who have invested a part of themselves in these tasks *("the teacher said we could get like a science area outside to grow plants and things but she never did it…I don't know why").* It is important to follow up on these activities and feedback to the children on the actions been taken, even if the outcome may be perceived as undesirable, so that they feel that their opinions are heard and of value (Gibson 2007).

This somewhat unconscious stance of power and knowledge is often overlooked in environments where the focus is on making well-intentioned changes to the environment 'for the children's sake'. However, the issue still remains and we, as adults know little about the child's becoming and cannot accurately see things from a child's perspective (Jones 2008).

On the topic of children as researchers, Kellett (2005) suggests that the journey moves on from researching on, through to research with children as a natural progression, accompanying a shifting in adult-child power divide and participation agendas. In our focus groups, children were excited to have the opportunity to be involved in the research. The excerpts below are an example of some of the comments made by the children during this study:

"This is the best thing I have done in school"

"I want to do this job when I am older"

"I'm enjoying this, it's actually kind of fun"

"I hope we do this tomorrow cause it's fun"

Jones (2008) suggests that there are large differences in adult and child becoming's. However, adults exist in a more powerful position in society and are often the producers of knowledge in research studies interested in children's worlds (Jones 2008). To further highlight this issue, when the children were asked about who should run future activities, one child responded *"I might ask the teachers who they want to be in charge"*. Future work should continue to explore ways in which the valuable contributions of children can be capitalised.

Effective injury prevention efforts at school are important and should address several factors (i.e., Individual, social, environmental and policy). However, improvements to the physical environment of the school through regular safety assessments, good quality maintenance, and repairing hazards immediately after they are identified (Salminen et al. 2013), can contribute to the safety of the school children without the need to restrict children's access to specific areas. Although the safety of children should be paramount, children should also be allowed some freedom to choose the activities they wish to take part in, to be able to begin to explore the concept of becoming physically literate. Physical literacy, focuses on the lived body, the embodied dimension of human existence (Whitehead 2007), therefore nurturing this aspect of children's lives will make a distinctive contribution to their becoming.

As mentioned previously, football dominated the playground, monopolising the space available. Cashmore and Dixon (2016) explain that football is inescapable, a sport ingrained into the fabric of communities. It would seem that this is also the case within primary school playgrounds, where football remains the activity dominating the available space. Therefore, as many children engage in this activity during break-times, it can be considered an important and effective catalyst for physical activity participation. However, the barriers that this dominance presents to children, either not interested in football or who have yet to demonstrate an acceptable skill level, cannot be overlooked (Thomson 2007; Pearce and Bailey 2011; Martínez-Andrés, Bartolomé-Gutiérrez, Rodríguez-Martín 2017). Conversely, as previous focus group studies with children have suggested, it is the lack of alternative space that is the main concern (Martínez-Andrés et al. 2017) and removing the facilities for football would remove opportunities for the large numbers of children who currently use football as a means of being physically active. Therefore, provision of additional space and/or more effective use of the current space, alongside more inclusive and enjoyable activities for male and female children is needed.

This study found similar individual (fun, enjoyment, physical competence), social (friendship, reciprocal relationships), environmental (equipment provision and available space) and policy level (staffing, rules and boundaries) barriers and facilitators to a physically active playground as previous qualitative investigations (Pearce and Bailey 2011; Hyndman et al. 2012; Parrish et al. 2012). However, this study is not without its limitations. Firstly, regarding the issues raised earlier in the chapter, I cannot remove my own subconscious adult filter and adult embodiment. However, the comprehensive, flexible and robust methods employed during child focus groups, in addition to the use of respondent validation techniques is a strength of this study and minimises any inaccuracies in the adult interpretation. Secondly, the use of and recognition of DTA as a qualitative method has previously faced criticism (Attride-Stirling 2001;

Holloway and Todres 2003). However, since the development of Braun and Clarkes' (2006) six stage process it has gained recognition as a qualitative tool in its own right, allowing "*a rich and detailed, yet complex account of the data*" (Braun and Clarke 2006; pg.5). Furthermore, the use of two authors throughout data collection, transcription and analysis enhances the trustworthiness of the findings presented in this study. Restricting recruitment to year five and year six children may have overlooked the barriers that exist in the younger KS2 children, particularly 7 year olds, who will have just been introduced to this new playground. This limits the ability to generalise this study's findings to all KS2 children who are likely to have a different playground experience. As this study did not receive any funding there was a limit to the number of schools and participants the two research staff could manage in the time frame. However, limiting the sample to two year groups from four schools allowed for a more comprehensive data acquisition, evaluation and synthesis. Finally, due to staff concerns with interviews (mentioned previously) all staff responses were completed using questionnaires (Appendix H), limiting a more in-depth investigation of the answers provided. It is hypothesised that a more comprehensive response and discussion would be possible using interview methods, and every effort should be made to remove the barriers perceived by members of staff in this study in future studies.

The findings from this qualitative evaluation provides an opportunity for primary schools which match the description of the schools participating in this study to reflect on primary school playground strategies and practices that are implemented at policy level. Furthermore, by attempting to understand the effect of the various complex interactions that exist within primary school playgrounds will help raise awareness within schools of the implications of supervisory interactions, judgement and management of behaviour, on the health and wellbeing of pupils (Hyndman and Chancellor 2017).

6.6 PhD implications

"If a lion could talk, we could not understand him"

My intention for Chapters 5, 6 and 8 was to move beyond conducting research on children, to conducting research with children positioned in an active role within the development process (Kellett 2005). Although, I acknowledge that the children in this study are very much 'co-participants' in an adult driven research project (Kellett 2005), future studies could consider moving the research into a more child-led role, answering issues that the children themselves have identified.

The following chapter (chapter 7) will draw on the findings from all previous studies in this thesis, before describing the final phase of developing a primary school playground intervention designed to increase FMS competence and the daily levels MVPA in primary school children (chapter 8). It is hypothesised that by continuing to include key stakeholders and children within primary schools in the research process, that the final intervention will be more easily integrated into the structure and policies already established within the primary schools. It is therefore important to establish a structure/framework that suits the environment children find themselves, free from restriction, which gives the child control over the activities they choose to engage in during their 'free' time (break-times and lunch time).

CHAPTER 7 SYNTHESIS OF FINDINGS

7.1 Introduction to chapter

The aim of this chapter is to summarise, discuss and synthesise the main findings of the studies within this thesis. This chapter will begin by revisiting the individual study rationales and aims. The following discussion will interpret, contextualise and synthesise the findings from each study. Finally, this chapter will provide some reflections on the strengths and limitations of the thesis prior to the recommendations for future research and the proposal of a primary school playground intervention (chapter 8).

7.2 Thesis recap and realisation of aims

The collective aim of this thesis was to provide a critical understanding of how the primary school playground could be more effectively and efficiently used to enhance children's FMS and physical activity levels. The first study in this thesis attempted to synthesise the current literature on the effectiveness of physical activity interventions utilising FMS on daily MVPA levels in 5 to 11 year old children (chapter 3). Chapter 3 also aimed to establish the proportion of future studies that are likely to find an effect of sufficient magnitude to reverse the current decline in childhood physical activity participation (chapter 3). Following this, chapter 4 sought to identify areas of the primary school playground that experienced the highest and lowest levels of MVPA during break-times to inform the implementation of future playground interventions. Chapter 5 aimed to understand children's enjoyment and satisfaction levels of current playground activities to understand some of the reasons for the playground behaviours observed in chapter 4. Identifying the playground activities and playground characteristics which elicited the highest levels of enjoyment would contribute to future playground planning and intervention. Further, chapter 5 aimed to explore any gender, age and adult/child differences in perceived enjoyment levels. Chapter 6, sought to determine current playground users (school staff and pupil) perceptions of the current physical activity barriers and facilitators on the primary school playground during break and lunch-times. A social-ecological exploration allowed for a multi-factorial understanding of the motivating and constraining playground factors (chapter 6). Outcomes from each of the aforementioned chapters were then used to inform the design and development of a primary school playground intervention aimed at increasing FMS competence and MVPA levels in primary school children (Chapter 8).

7.3 General discussion

The childhood years are an important period for establishing healthy lifestyle behaviours, such as physical activity, that can track through adolescence and into adulthood (Telama 2009; Telama et al. 2014). However, physical activity participation in primary school aged children is inadequate (HSE 2008; Sport England 2019) leading to an increase in publications related to physical activity interventions in children and youth (van Sluijs and Kriemler 2016). However, few intervention studies follow a thorough needs assessment and carefully designed program (van Sluijs and Kriemler 2016). Therefore, the following sections in this chapter are designed to highlight and synthesise the outcomes of specifically designed studies with the collective aim of contributing to an experimental and theoretically informed physical activity intervention.

7.3.1 Inclusion of fundamental movement skills

Despite previous research highlighting the importance of FMS competence to physical activity participation (Salmon et al. 2008; Stodden et al. 2008; Lopes et al. 2012; Jago et al. 2019; Tsuda et al. 2019), very few primary school leavers exhibit a mastery level of FMS (O'Brien et al. 2016). Previous research has also identified positive associations between FMS competence and MVPA levels (Lubans et al. 2010). Therefore, it is not surprising that with so few primary school children demonstrating mastery of FMS that only 31% of primary school aged children achieve the current UK CMO guidelines (DoH 2019) for MVPA (Steene-Johannessen et al. 2020). The random effects meta-analysis from chapter 3 in this thesis highlighted that physical activity interventions that include FMS in their planned activities improved daily levels of MVPA in 5 to 11 year olds by a pooled mean difference of 4.3 minutes, compared to controls (see chapter 3, pg.82). It was established in this chapter that a difference of more than 3.6 minutes per day of MVPA (MCID) between intervention and control groups would contribute to reversing the decline in MVPA levels as children age. Therefore, it was concluded that physical activity interventions that focus on FMS have the potential to provide positive effects on MVPA in children. However, as a result of the between study heterogeneity and the variability in intervention implementation (Table 3.2, pg.74), the prediction intervals (the effects likely in similar future studies) were large, suggesting there were differences in the way the FMS activities were conceptualised and operationalised. This assumption was supported by the meta-regression from chapter 3, whereby interventions which fully embodied the concept of FMS, established by meeting Logan et al. (2018) criteria and by including a measure of FMS, resulted in greater improvements to daily MVPA, whilst substantially reducing the between study heterogeneity (tau). These findings support the previous suggestion (Rudd et al. 2017b) that interventions focussing on instructionally and developmentally appropriate FMS provide a greater likelihood that children will become proficient in FMS and consequently increase MVPA levels (Rudd et al. 2017b).

As mentioned on page 63 in the footnote, chapter 3 was prepared and submitted for publication but unfortunately did not meet the standards of the journal. However, one of the reviewer's comments stood out on criticising the authors (MG and others) understanding of FMS. The comment reads *"FMS interventions are **expected** to improve physical activity, those two go hand-by-hand; this is not surprising"* (reviewer one). The "expectation" that an FMS intervention will, without question improve physical activity is potentially why some of the intervention studies included in the meta-analysis for this chapter experienced a decreases in MVPA post intervention (Weber et al. 2017; Adab et al. 2018; Taylor et al. 2018), or experienced no difference when compared to controls (Telford et al. 2016; Jago et al. 2019). A credulous expectation of positive outcomes may lead to future interventions neglecting to provide a consistent assessment of FMS. Furthermore, few studies from chapter 3 utilised a follow up or a longer-term assessment of outcomes, overlooking the developmental nature of ‘mastering’ FMS. This chapter (chapter 3) also highlighted that many of the studies which observed positive intervention effects initially, experienced a reversal or decline following the termination of the intervention (Table 3.2 chapter 3, pg.74), suggesting the intervention effects represented a more acute movement performance rather than a sustained development in movement competence.

The systematic review synthesis in chapter 3 highlighted FMS interventions focussed primarily on the school playground are lacking. The multi-component studies included in the review had policies targeting the promotion of physical activity during school break-times, however these were implemented without an assessment of current playground physical activity behaviours and MVPA levels. Implementing intervention activities on the already more active areas of the playground could have presented barriers to children already using those areas, contributing to a decrease in break-time activity levels and daily MVPA. Chapter 4 of this thesis was designed to address this limitation by identifying playground areas with high and low physical activity levels.

Chapter 3: key points for future intervention development:

A. Developmentally and instructionally appropriate FMS – accurately conceptualised.
B. Regular measurement of FMS throughout the intervention period to ensure FMS activities remain targeted at the appropriate level.
C. Measurement of FMS pre and immediately post intervention and following a suitable follow up period.
D. Accurate physical activity measurement – if designed activities consist of combinations of throwing and catching activities and locomotive activities then the placement of the measurement devices should be considered (e.g., hip and wrist worn accelerometry).

7.3.2 The primary school playground

With opportunities for childhood play outside of the school environment on the decline (Hooferth and Sandberg 2001; Carver et al. 2008; Carver et al. 2017), there is even more pressure on schools to provide safe, enjoyable and fun physical activities that contribute to achieving recommended levels of MVPA. Previous findings have highlighted the positive association of outdoor time with physical activity levels and FMS competence (Plotnikoff et al. 2014; Niemistö et al. 2019), therefore positing the school playground as one environment offering potential ‘intervention’ space.

There is a contrast in the literature examining children’s daily physical activity trajectories. Riddoch et al. (2007) suggested break-times were already the most active periods in a child day, whilst Wiersma et al. (2019) identified the period immediately after school to provide the highest level of activity in children. There are a number of methodological differences in these studies (see chapter 2, section 2.4.4, pg.55 for a more detailed examination), however, additional environmental differences (playground size, equipment provision, available space, weather and the level and type of supervision) may have had an effect on the activity levels of participating children. These studies collected physical activity data using accelerometry only, therefore unable to accurately establish the effect of any environmental and contextual factors on the physical activity levels of children during break-times.

Chapter 4 in this thesis utilised direct observation to measure the physical activity levels and the contexts in which they occur during school break and lunch-times. The decision was taken to use the SOPLAY to be able to measure the activity levels of the whole playground population during the break periods and to be able to accurately capture valuable contextual data. Findings from this study identified that not only is there a large percentage of children not achieving a MVPA threshold during break and lunch-times (76%), but that physical activity levels of children during these periods are influenced by a number of external and internal factors such as; organised activities, effective supervision and access to appropriate equipment.

Chapter 4, though limited by its case study methodology (observations in one school) highlighted that appropriate adult supervision during school break-times can have a positive effect on children's MVPA participation and that organised activities, though restricted to specific areas of the playground can also increase participation in MVPA. Furthermore, the provision of additional equipment led to a decrease in MVPA observations during break-times. These findings have important implications on the planning and management of future playground activities. This finding is also important as it is in contrast to previous observational research which found that adult supervision had a negative effect on children's activity levels whilst providing equipment to children increased MVPA observations (McKenzie et al. 2010). This suggests that the behaviours and actions of playground supervisors (positive reinforcement vs. punishment), the management of the playground (provision of equipment, organised games, and encouragement) and the type of playground equipment provided (age and developmentally appropriate) can either positively or negatively influence children's engagement in MVPA.

Fundamental movement skills were not objectively measured in chapter 4, however, trained observers were asked to identify the main activity type by recording the movement categories observed during video clips. The data from these observations are presented below (Table 7.1). Taggart and Keegan (1997) highlighted that children take part in predominantly running, jumping and kicking activities on the school playground whilst object controls skills (excluding kicking) are not frequently engaged in. Although there is a twenty year gap between data collection for Taggart and Keegan and this study, the findings presented in Table 7.1, would still support these earlier findings, with the largest proportion of observations from chapter 4 in this thesis coming from locomotion (running, walking, hopping, jumping) and from locomotion combined with balance/stability (climbing, balancing, jumping). One limitation with this method is that chase games may have been scored as locomotion but involve balance and agility when evading other children and playground furniture (benches, etc.) (Taggart and Keegan 1997).

In addition, this unrefined assessment is largely subjective as one observer may have scored football as locomotion with object control, whilst another may have considered the importance of balance and stability when dodging members of the opposing team without losing balance. Finally, there was no assessment of inter/intra observer reliability conducted on these scores and therefore they should be interpreted as simple (non-systematic) observations only.

Table 7.1. Main skill categories observed during chapter 4's data collection

	Skill categories							
	L	OC	B	L, OC	L, B	OC, B	L, OC, B	None
Observed Counts	261	17	62	92	110	0	3	71

Abbreviations: B = Balance; L = locomotive, OC = Object control

However, what is unclear at this stage is whether children adopt these physical activity behaviours due to the physical constraints of the playgrounds (lack of well-designed throwing and catching areas) and their movement competencies, or whether the children's enjoyment of particular playground activities influence playground choices. Furthermore, does enjoyment of playground activities supersede physical competence when deciding on playground activities?

Chapter 4: key points for future intervention development:

A. Playground areas which promote climbing, team sports and adventure play currently promote the highest levels of MVPA during break-times. This should be considered when deciding on any specific playground areas to target in the intervention as to not reduce MVPA levels in these already active areas
B. Consideration should be given to the allocation of playground space when designing activities in order to accommodate large enough numbers of children in the areas promoting MVPA

C. Consideration should also be given for the inclusion of adult supervision and organisation; and to the provision of age and developmentally appropriate equipment.
D. Encouragement of a wider range of FMS
E. Low MVPA levels observed during break and lunch-times

7.3.3 The child's perspective (part 1)

Previous school-based physical activity interventions have shown little impact on daily MVPA levels in the longer term (Ridgers et al. 2010; Love, Adams, van Sluijs 2019), suggesting current school-based efforts need to consider more sustainable approaches (Morgan et al. 2013; Daly-Smith, Quarmby, Archbold et al. 2020). Where previous school-based studies might have failed is the reliance on methodologies driven by research teams with little knowledge of the complexities of the school environment. This externally driven approach, with limited input from key stakeholders within the school environment, at user (children), middle management (staff) and policy (head teachers) level ignores the value of the 'insiders' perspective (Kellett and Ward 2008) and the valuable contributions children themselves can offer (Kellett 2005).

Campbell et al. (2007) highlights the importance of understanding and acknowledging the levels of complexity in the intervention environment. For example, an intervention targeting the increase in children's MVPA during PE needs to consider the individual (motivations, preference, gender etc.), the practitioner (staff and researchers), the social context (friendship, bullying, and peer support), the school culture (rules, boundaries, sport etc.) and policy (importance placed on physical activity) complexities. An intervention at one level (practitioner) could be contradicted or promoted by actions at other levels (policy) (Campbell et al. 2007), whereby improving the promotion practices of playground staff will have little to no effect on children's MVPA if the social, environmental and policy factors obstruct or oppose the outcomes.

Following the concept of the SEM, chapter 5 in this thesis was designed to explore the enjoyment levels of break and lunch-time activities and begins to identify specific individual, social and environmental factors to children's enjoyment of playground activities that might influence activity levels. The findings reported in chapter 5 support and explain some of the observed behaviours from chapter 4. In chapter 4, female children were observed more frequently and in larger numbers in areas promoting social interaction, whilst also reporting a higher level of enjoyment for "talking with friends" (chapter 5). In addition, female children reported high levels of enjoyment for climbing activities (chapter 5) which support the relatively higher number of females observed in areas promoting climbing (chapter 4). The findings from chapter 5 are important as physical activity enjoyment is considered the biggest driver of participation in physical activity (Sport England 2019) and is essential in achieving the recommended amounts of daily MVPA (Welk 1999; Sport England 2019). Focussing on promotion of activities which children enjoy is likely to lead to increases in physical activity participation rates and movement competence.

Findings from chapter 5 reflect children's enjoyment levels of the playground environment available to them at the time of the survey. The primary school playground is predominantly designed and managed by the staff at the school in line with an adult agenda (chapter 5, pg.143). This limitation in playground planning is highlighted by the differences between pupil (child) and staff (adult) self-reported enjoyment levels. Chapter 5 from this thesis therefore strongly recommends that future playground design actively involve the child in the identification, design, prescription and management of activities and play spaces.

Chapter 5: key points for future intervention development:

A. No obvious differences in survey totals between males and females at KS1 and KS2. However, a significant interaction cannot be ruled out as CL are at or above SESOI (individual and social level).

B. Subtle gender differences for individual survey items – support observed behaviours in chapter 4
C. Highest enjoyment levels were recorded at social levels (playing and talking with friends).
D. Staff and pupils self-reported enjoyment scores differed at individual, social and environmental levels of the SEM. This highlights the importance of child input in design/planning activities.

7.3.4 The child's perspective (part 2)

Discrete differences in enjoyment levels between male and female children (chapter 5) and that the males and females observed in playground areas more favourable with the opposite gender were as active as each other (chapter 4) suggests that rather than assume there are specific populations (i.e., male/female) that seek out more active areas of the playground, it may be more effective to establish what the existing barriers and facilitators to physical activity are for these populations using a multi-factorial, socio-ecological approach (chapter 6).

Consistent individual, social and environmental level determinants of physical activity participation continue to be reported (Sallis Bull, Guthold et al. 2016) highlighting the importance and usefulness of using a socio-ecological approach to understanding physical activity (Rhodes, Saelens, Sauvage-Mar 2018). Despite the interaction tenet of socio-ecological frameworks recently receiving debate, specifically in relation to environmental accessibility and individual motivation (Rhodes et al. 2018), they have been used extensively in health behaviour research with positive results (Salmon and King 2010; Hyndman et al. 2012). Furthermore, the presence and importance of the interaction tenet between the multiple levels of the SEM has been previously identified (Thesis chapters 5 and 6; and Salmon and King 2010).

Friendship and positive peer relationships are a key factor in facilitating physical activity participation and in deciding which play spaces to engage with during break and lunch-times (chapter 6; Pearce and Bailey 2011; Hyndman et al. 2012; Parrish et al. 2012). In addition, children reported 'perception of physical competence' as a reason for participating in their chosen playground activities. Focus group outputs from previous research found that the desire to master certain skills needed to engage in play drove children's decision making during break-times (Snow et al. 2019). Increases in a child's competence and confidence in their ability is likely to result in participation in physical activity during other parts of the day (Parrish et al. 2012). Despite the facilitative effect that perceived competence had in this study, the desire for peer acceptance, popularity and multiple 'quality' friendships was a bigger driver of playground activity choice. This finding support those from previous focus groups (Parrish et al. 2012) and is important as it highlights the positive impact of positive peer relationships, reciprocal friendships and social position on physical activity participation, irrespective of physical competence. Furthermore, participation in physical activities for social reasons presents opportunities for those children motivated by friendship to develop skills and participate in activities they may otherwise have avoided.

The observed differences in child and adult responses highlight the very different view children and staff have about the role of break-times and what constitutes 'acceptable use' of the playground. Chapter 6 highlights a number of inter-related environmental boundaries and school policies that act to restrict children's explorations and activity level during the only period of the day when children are 'free' to play (rules, boundaries, lack of resources, use of playground areas for curriculum activities during break-time).

Chapter 6: key points for future intervention development

A. Differences in the perception of the playground – child vs adult agenda
B. Adult/child power divide evident in the child embodiment of the adult rules, regulations and agenda – children perpetuate the behaviours of those in power (staff) but can this be utilised to facilitate a more positive playground experience.

C. Barriers and facilitators identified at all levels of the SEM and interaction between levels is evident
D. Traditional playground hierarchies act to promote and prevent physical activity engagement for different groups (hegemonic masculinity)
E. Lack of valuable and sustainable investment in the playground and break-times.

7.4 Implications for practice

Findings from this thesis highlight the complex interactions that exist in the primary school playground and offer a valuable insight for schools and researchers when considering the implications of adult and child interactions and the management of the playground on physical activity engagement and the health and well-being of pupils. Despite the case study methodology applied in chapter 4, the low levels of MVPA observed during break-times, in addition to previous research presenting similarly low levels of MVPA (Mota, Santos, Guerra et al. 2003; Ridgers et al. 2006; Anthamatten et al. 2014), suggests the primary school playground is an environment that could be manipulated to benefit primary children's MVPA levels.

However, there is no statutory requirement for schools to provide children with a break in the school day (Baines and Blatchford 2019) and the amount of time provided for break-times has given way to more academic pursuits (Erwin et al. 2014; Baines and Blatchford 2019). Therefore, it is important to develop time efficient and sustainable playground activities that encourage a higher level of movement competence and a greater amount of MVPA. By encouraging schools to consider the playground as a valuable resource, and use need not be restricted to non-curricular periods in the day is hypothesised to encourage a more effective use of this outdoor space by children during break and lunch-times. However, with the reported reduction in time allocated for break-times (number and duration) (Baines and Blatchford 2019) it is essential that the current break and lunch-time allocation is not sacrificed for planning activities (e.g., designing activities) as this would lead to lower activity levels and an increase in sedentary behaviour during these periods. A more efficient use of curricular and non-curricular time (class-time and homework) to develop activities that can be practiced during break-times is advised to make a more effective use of the playground during this time.

It is important to ensure that stakeholders at all levels (staff, children and research) are involved in the development of interventions to ensure that the agenda's and priorities of each group are heard and represented during development and implementation (Kellett and Ward 2008). As the aim of the intervention is to increase break-time and ultimately daily levels of MVPA in children, it is essential that the children feel empowered and supported throughout the decision making process (Kellett 2005; Jones 2008) to encourage longer term investment in the intervention activities. However, for this to occur there needs to be a shift in the way the playground is currently supervised and managed.

Chapter 6 discussed the potential the PPESP has in contributing to increases in engagement in regular physical activity during break and lunch-times (DfE 2019). However, only one school from this thesis mentioned the playground or break-times in their PPESP plan and allocated £750 from their £19,520 budget. In addition, the reported lack of resources available during break and lunch-times (staff and equipment) (chapter 6) suggest the primary schools that participated in the studies in this thesis are not currently using their playgrounds effectively with an inadequate investment in children's physical activity and health during these times. One avenue to explore in the development of future interventions is to address the way in which primary schools are currently investing their PPESP so the playground and break-times receive a more valuable share. Although it is too early to assess its impact, the recent UK government investment of £29 million for teacher training and facility management may support the facilitation of such interventions.

During the course of this thesis, a common theme emerged; which was that of the dominance football has on the playground. Football continues to monopolise space on the school playground (Thomson 2007; Martínez-Andrés et al. 2017) and acts as a facilitator of physical activity for many children. The requirement football has for a larger number of participants than most playground games also promotes social interaction and plays an important part in securing reciprocal relationships (Oberle et al. 2009). However, for those children who do not play football, it is perceived as a barrier to physical activity due in part to these children avoiding the space dominated by football for fear of injury and because of the ‘masculine’ displays of dominance (chapter 6; and Renold 1997). Furthermore, the activity of football is rewarded with the premium play space, leaving those children who either do not want to play football or who have been deemed not good enough by their peers (Martínez-Andrés et al. 2017), fighting over the peripheral playground space (Thomson 2007). To facilitate a physically active break-time for all children, it is essential that the domination of football in primary schools be managed accordingly by school staff (Hyndman et al. 2012), by a fairer distribution of play space (Martínez-Andrés et al. 2017) and by providing more appropriate alternatives.

Chapter 3 highlights the beneficial increase to daily MVPA levels in children who participate in an appropriately designed FMS intervention. Evidence suggests that mastery of locomotion skills are a key determinant of physical activity participation in childhood (Foweather 2010); whilst mastery of object control skills in childhood is associated with higher levels of physical activity in adolescence (Barnett et al. 2008). This reinforces the importance of developing these skills before graduation from primary school. However, many primary school leavers do not currently demonstrate mastery of FMS (O’brien et al. 2016) supporting the importance of the early years in developing FMS (Jones et al. 2020) but also in identifying the final years of primary school (year five and year six) as an essential period for practicing and mastering skills. Fundamental movement skill interventions targeting these year groups would ensure a larger percentage of children leave primary school showing a higher level of proficiency and therefore more likely to achieve physical activity recommendations in the future.

Physical education currently has the responsibility for the teaching and practice of FMS in primary school. However, few primary schools invest the time and money needed for staff to become a specialist PE teacher (Griggs 2018). This has important implications for future interventions aimed at utilising current primary school staff. For FMS interventions to be effective they need to have an element of teaching and coaching and include activities that are developmentally appropriate (McKenzie et al. 1998; Stodden et al. 2008; Barnett et al. 2016a; Barnett et al. 2016b). Therefore, the inclusion of FMS teaching workshops and support for primary school staff should be considered as a component in future interventions.

7.5 Reflections and research implications

During the course of this thesis there were a number of methodological implications that arose, relating predominantly to evaluating physical activity and working with primary school children whilst in the school environment. Though it is acknowledged that the following issues are a result of the planning, approval, recruitment and evaluation strategies used in this thesis, they will no doubt have wider implications for future work in this field.

7.5.1 Recruitment and ethics

The idea for this PhD project was born out of communication with a local school who had an interest in finding out how their school playground and new playground equipment could be “better used”. This was the key driver of this theses which was then shaped into a research question and there became the need to acquire research ethics. Although this is an essential part of the research process, to ensure confidentiality and participant/researcher safety, the time it took to receive ethical approval for each project meant that the initial school was kept waiting for 6 months before participant recruitment could begin. Furthermore, a change in ethical guidelines during my PhD meant the method of recruitment and the identification of participating schools had to change for future studies. Due to the change in guidelines, recruitment of schools for chapter 6 could not begin until ethics had been granted. Once schools had expressed an interest (through email response) the contacts at the participating schools (head teachers and year leaders) expressed concerns over the level of detail in each of the research document (participant information sheet, consent and assent forms) and requested they be made easier for parents to understand. The general response from schools was that *"parents just won't read that"*. This meant that requests for ethical amendments were then required, delaying recruitment further.

Finally, the work patterns and priorities of the participating schools and my own were very different, and I was quite often waiting a number of weeks (on more than one occasion) for schools to return documents and to arrange data collection dates. Gibson (2007) states that scheduling creates a number of challenges when working with children and schools due to their already busy lives (school timetable, holidays, homework, exams, after school activities). Identifying a time, day and location that suits the participants and giving a choice of a preferred location has been suggested to be the most successful approach (Gibson 2007). However, there seems to be a small window of time that each school has available, and identifying this time and then getting access to it can be challenging. Furthermore, if this time appears in a period of the day when children are fatigued such as at the end of the school day or after school, it may be hard to maintain children's concentration levels (Kennedy, Kools and Krueger 2001).

Although some of these situations are unavoidable when working within primary schools, I believe contacting the schools and involving them in the research process, from the earlier planning stages (including applying for ethics) and throughout delivery would reduce some of these delays with the research project receiving a higher level of priority within the school's scheduling. This idea was somewhat reinforced in the final year of my thesis. I attended a district primary schools conference to present some of the findings from my thesis. This generated a significant amount of interest in my PhD project and led to discussions with school contacts about how they could be using their playground space more effectively. In future, attendance at similar conferences, where the findings from research can be delivered directly to practitioners would help raise the profile of my research and highlight the support and expertise that research staff can offer.

7.5.2 Measuring children's physical activity on the playground (chapter 4)

The primary school playground seems to offer a wide array of playground activities (chapter 4) that result in high levels of enjoyment for most children (chapter 5). However, chapter 5 and 6 highlighted the importance of friendship and positive peer relationship in the decision to occupy specific playground spaces and engage in particular playground activities. Future studies interesting in using direct observation to measure playground physical levels and behaviours, as part of a wider project of intervention development could consider the use of the system for observing children's activity and relationships during play (SOCARP) (Ridgers, Stratton and McKenzie 2010). The decision to use the SOPLAY in this thesis was based on the variety of contextual factors it measured using momentary time sampling of play behaviours of all the users during the window of observation. The use of video recordings and the ability to score retrospectively, was believed to better suit measurement of this environment.

The SOCARP scores three contextual variables related to the environment (presence of adult supervision, provision of equipment and temperature). Furthermore, it records the number play activities and social behaviours, the proportion of intervals/time spent in each group size, activity type, and type of social interactions by the target child (Ridgers et al. 2010) which would have been beneficial to this thesis. However, the SOCARP was designed to track individual children for a period of time (dependent on duration of break-time and population density) which would not have allowed for MVPA comparisons between the many play spaces (target areas) available during break-times. The SOPLAY, however, was designed to allow these comparisons to be made and provides mapping protocols to accurately identify target area boundaries (McKenzie 2012). Furthermore, use of the SOPLAY allowed for a larger number of children to be observed at one time. There are key benefits to both direct observation methods presented here. Future studies interested in observing the play behaviours of children break and lunch-times should consider using a combination of these methods to accurately record key contextual variables (SOPLAY) and the social behaviours (SOCARP) of children on the playground.

During the first familiarisation session at the school, it became very apparent to the team that live observations in a primary school playground of children's activities levels was unrealistic due to the environmental complexities and the chaotic activities of break-time (Thomson 2007). To ensure minimal reactivity to the researchers the observation viewing point was in some cases quite far away from the child getting observed. Thomson (2007) had similar issues relating to how fast and mobile children were and the fact they were all in the same uniform; this meant that at times it was hard to distinguish children as they all looked the same. A limitation to this method, particularly when associating to FMS is that it may not always be possible to identify children with specific learning difficulties or a development delay which could have an effect on the overall observed counts for the various physical activity categories.

There are clear constraints on what can be achieved during live observations (Thomson 2007) and continuing with this approach would have resulted in an inaccurate representation of the children’s behaviours. Therefore, there were two options discussed: 1) increase the amount of research staff on the playground so that one pair of researchers were scoring only one area, resulting in a higher number of observations per area; or 2) use video cameras to record the playground zones and score retrospectively. In addition to reasons presented in chapter 3, the research team agreed that the second option was the preferred choice for the following reasons: 1) Method one would have resulted in an increased presence of unfamiliar research staff on the school playground leading to a reduction in natural behaviour and increasing the risk for reactivity; 2) Method two would reduce the presence of the research team, increase the number of possible observations by removing the need for live scoring and note taking; 3) Less time spent in the school environment allowing for a more efficient turnaround of the research output for this thesis and to produce a school report; 4) The ability to score the video clips sat at a computer allowed for repeated observation of each clip to be confident in assessment; and 5) as it allowed for an immediate electronic transfer of scores into a Microsoft excel spreadsheet that was used to table and group the data by target area, gender, and activity level.

However, this method presented its own challenges as identifying genders of children at a distance, wearing the same clothing and sometimes obscured by playground furniture (trees, climbing frames) was difficult. The decision was taken to not score the behaviours of children that could not be accurately identified. The measurement methods used in chapter 4 provided some valuable data. However, the whole process, from initial training through to accurate scoring and analysis was very labour intensive and time consuming.

The decision to present the outputs from chapter 4 as episodes (counts) of MVPA observed during break-time as opposed to numbers of children observed was a result of many meetings and discussions with my PhD supervisory team. Previous studies using momentary time sampling has recording observations as the number of children observed in physical activity behaviours during the observation window of time (normally 30 seconds). The number of observations within each physical activity behaviour is then used to estimate energy expenditure of children using pre-defined constants for sedentary, LPA and MVPA (McKenzie, Sallis, Nader et al. 1991). However, the major limitation with this method is that there is no guarantee that the children observed during each time window are different children or indeed the same children revisiting the area. Therefore, it would be incorrect to assume that the scores recorded represent separate (between groups) or repeated (within groups) visits/children. As the purpose of this study was to measure the difference in activity levels between target areas and to identify the environmental characteristics of the areas which promoted higher levels of MVPA, there was no requirement to identify individual children. However, as observations are a measure of the perception of physical activity rather physical activity, per se (Reilly, Penpraze, Hislop et al. 2008), future studies could consider a combination of observations (for important contextual data), accelerometry for objective physical activity measurement (accurate reporting of intensities) and global positioning devices (GPS) to track individual children’s locations throughout break-times.

7.6 Thesis strengths and limitations

The implications related to FMS measurement and complex nature of physical activity measurement in children have been discussed previously in this thesis. However, studies using a more accurate holistic measurement of children's physical activity (e.g., including measurement of the more discrete upper body movements such as throwing and catching) are essential to establish true associations between FMS and MVPA (Duncan et al. 2019). The inability to fully explore the relationship between the FMS and MVPA outcomes in chapter 3 is a limitation of this thesis. However, due to the multiple measurement tools used and the multiple methods of reporting outcomes for FMS (e.g., separate skill category scores; FMS totals; gross motor quotients (GMQ) from different measurement batteries; and use of individual skills), in addition to the varied method of reporting physical activity (chapter 3. Table 3.3., Pg.79) in the included studies that reported FMS; running a meta-analysis on FMS and MVPA in this chapter would not have advanced the understanding on this relationship.

As mentioned in chapter 3, only Salmon et al. 2008 and Bryant et al. 2016 measured both FMS and MVPA post intervention and at follow up. Future studies interested in establishing the effect of FMS on physical activity levels of children should consider the timings of outcome assessments and the inclusion of longer term follow ups to gain a greater understanding of this relationship over time and as FMS competence develops.

A strength of this thesis is its use of the SEM (Davison and Birch 2001) to explore the complex, multi-faceted environmental determinants of physical activity in the primary school environment. A key finding from the qualitative exploration in this thesis was the importance of friendship and social relationships. These findings support previous socio-ecological studies examining children's play experiences (Coulter and Woods 2011; Hyndman and Chancellor 2015; Hyndman and Lester 2015). However, one limitation in chapter 5 was the use of scale with a limited number of social items with poor internal consistency (Table 5.2., pg.126) (Hyndman et al. 2013). Given the complex nature of relationship building that exists on the playground during childhood (Renold 1997; Oberle, et al. 2009) future research interested in understanding children's playground behaviours and dynamics should consider a socio-ecological scale with a larger emphasis on the social components.

Finally, although not directly measured or addressed in this thesis, the motivational climate in which physical activity interventions are delivered is of importance. Research on the instructional climates for effective movement skill development in children has primarily focused on two approaches; low autonomy (LA) or a teacher-centred approach (Goodway and Branta 2003; Robinson and Goodway 2013); and a mastery motivational (MMC) or child-led approach (Martin, Rudisill, Hastie 2009; Robinson 2011; Robinson and Goodway 2013). Both LA and MMC have been found to be effective in the development of movement skills (Robinson and Goodway 2013). However, an instructional climate which follows a LA method of prescription and instruction is centred more on teacher control and direction with children exposed to constraints prescribed by the instructor, often an adult. Not achieving the requirements of the task/goal would be perceived by the child as failing, having low skill competence and consequently lead to low self-efficacy. This is important in terms of movement skill development and learning, as FMS competence and perceived skill competence have been shown to be positively associated to MVPA levels (Stodden et al. 2008; Jones et al. 2020).

In contrast, a MMC has been found to be effective in the retention of positive changes in movement skill development (Valentini and Rudisill 2004) as it promotes a more positive task-orientation in achievement of the identified goal. When utilising MMC, children have the freedom to explore the learning environment, controlling the effort and time devoted to the task with success evaluated against self-referenced criteria (Bowler 2009). However, a more effective instructional climate might be more flexible, offering freedom for children to freely navigate their environment (MMC) bolstered with the option of instruction from a suitably trained adult (LA), should they choose it. This idea is supported by previous research which suggests that both LA and MMC can significantly improve movement skills when the skills are developmentally and instructionally appropriate (Robinson and Goodway 2009; Palmer, Chinn and Robinson 2017). Allowing a more flexible utilisation of a mixture of methods would better suit the needs of the child and address Jones (2008) perspective of childhood as other from adulthood.

7.7 Conclusion

Each chapter in this thesis is a valuable step in the needs assessment and mapping (van Sluijs and Kriemler 2016) of a future primary school playground intervention (presented in the next chapter). This thesis has explored not only the importance of including FMS in physical activity interventions but the importance of accurately conceptualising FMS prior to intervention delivery and design (chapter 3). Playground physical activity during break-times appears to be affected by a number of variables at each level of the SEM. For example, playgrounds which promote a wide variety of activities are likely to encourage higher levels of MVPA. However, individual (likes/dislikes), social (number and quality of friendships), environmental (available space) and policy level (staffing/resources) constraints determine children's activity choices and MVPA levels during break and lunch-times. Exploring and understanding the socio-ecological determinants of playground physical activity during school break-times is an essential part of designing, conducting and evaluating complex environmental interventions. The next stage in this work is to design and evaluate a pilot playground intervention aimed at increasing FMS and MVPA levels in primary school children. As established previously in this chapter, targeting children in the older year groups (year 5 and year 6) will increase the percentage of primary school leavers demonstrating a higher level of FMS competence. Incorporating intervention components informed by the socio-ecological determinants of children's playground behaviours established in this thesis is hypothesised to lead to sustainable, longer-term improvements in physical activity engagement and MVPA levels.

The following chapter presents an intervention proposal underpinned by findings from each of the previous studies in this thesis. The intervention proposal has been designed to encourage a higher level of MVPA during break-time whilst developing FMS competence. It is hypothesised that with increases in movement competence developed through a mixed motivational climate will lead to increases in daily MVPA levels.

Successful implementation and evaluation of the proposed pilot intervention will complete a comprehensive development activity aimed at optimising a complex physical activity intervention. Achievements and future aims for this project can be seen in Figure 7.1 below.

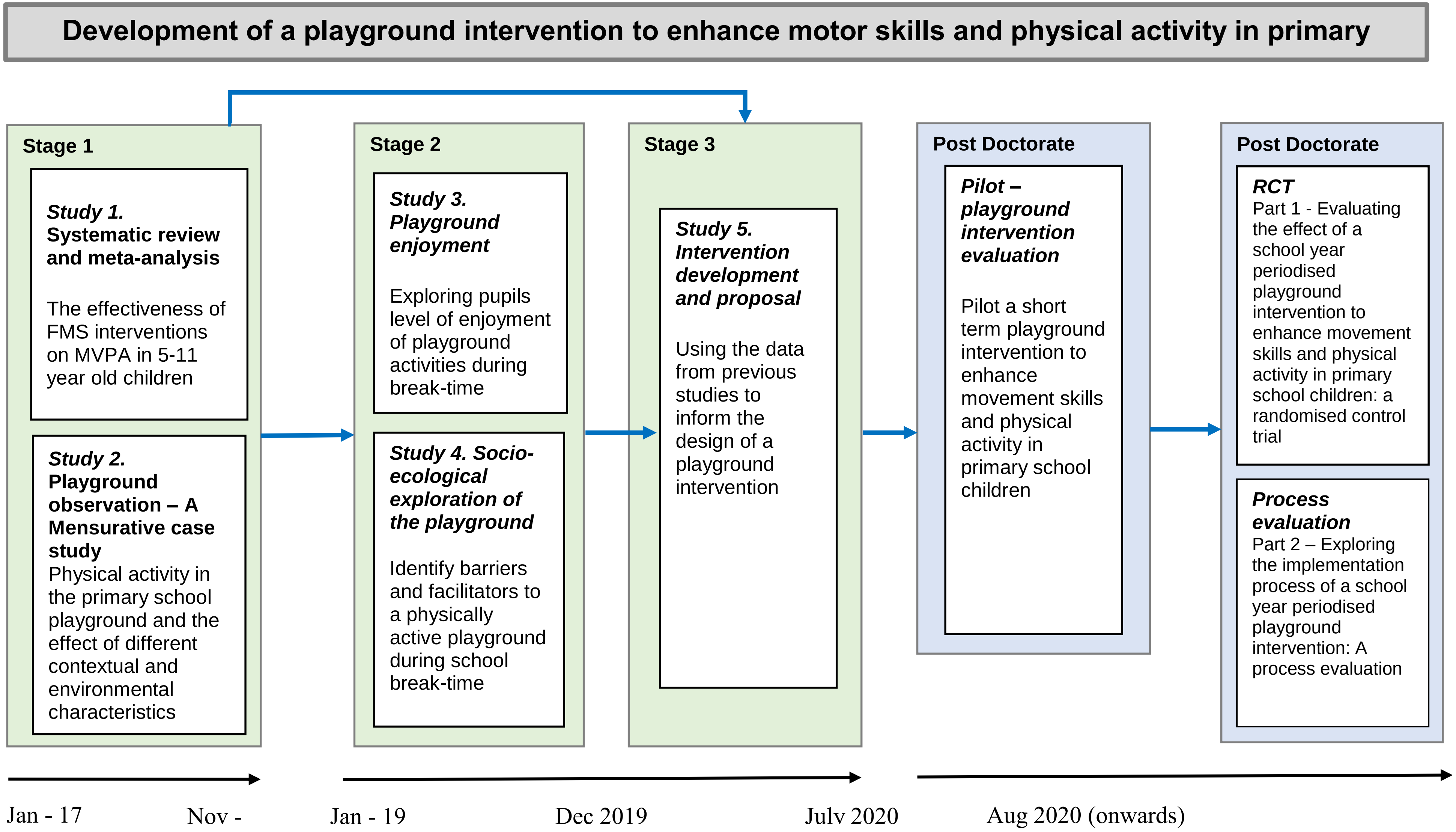
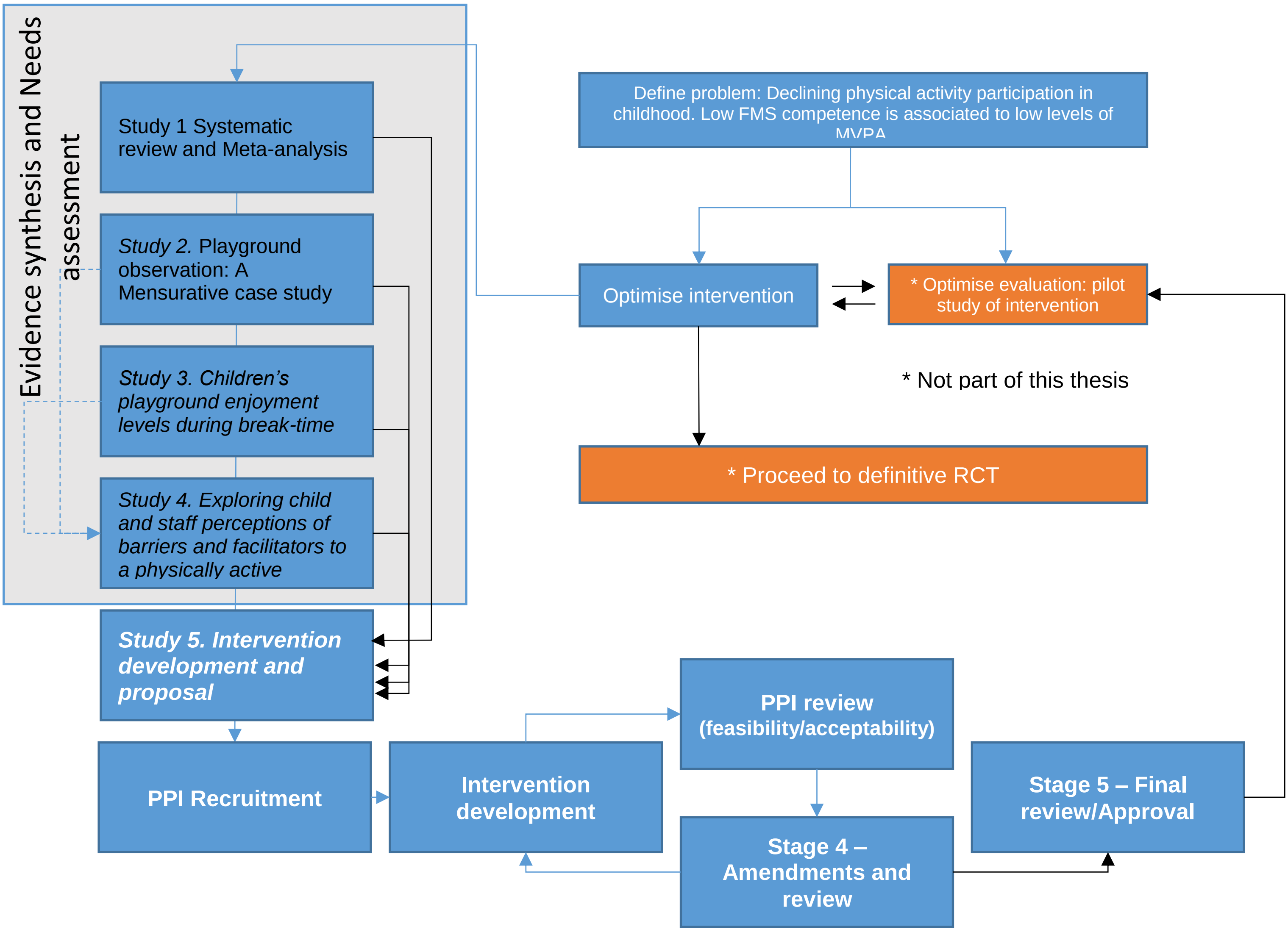


Figure 7.1 PhD study framework including proposal for Post-doc activities

CHAPTER 8: PRIMARY SCHOOL PLAYGROUND: INTERVENTION DEVELOPMENT AND PROPOSAL



Chapter aim: To present a proposed primary school playground intervention aimed at enhancing FMS competence and MVPA levels in primary school children.

Study design: Pilot intervention proposal

Future aims for project: 1. Evaluate the effectiveness and feasibility of the intervention in a pilot cluster (school) randomised control trial. 2. Assess feasibility of the pilot intervention. 3. Optimise intervention and evaluation prior to funding application and a definitive randomised control trial.

8.1 Introduction

The main aim of this supplementary chapter is to present the final process of the design and development of a primary school playground intervention. The key findings from each of the chapters in this thesis were identified by following a flexible utilisation of the MRC framework (2008) for developing complex interventions as recommended by Campbell, Murray, Darbyshire et al. (2007). This chapter begins by presenting the methods and recruitment of key stakeholders and the FMS/physical activity steering group. Section 8.3 presents the key components to the intervention, the phases of intervention delivery, the SEM components each phase targets and the thesis chapter findings that provide the underpinning theory for their inclusion. The chapter concludes with early considerations for the successful evaluation of the planned pilot intervention and future directions.

8.2 Intervention development and design

8.2.1 Initial discussions

Research outputs from each chapter in this thesis were presented and discussed with an existing FMS and physical activity steering group at Teesside University. As mentioned in chapter 6 (pg.160) the steering group consisted of researchers, academics, trained PE teachers, coaches and sports development officers with an interest and expertise in this research area. The aim of this initial discussion was to formulate a needs analysis and structure for a playground intervention using the study outcomes from this thesis and the group member's previous knowledge and expertise in this area. The discussion group outcomes were then used by myself to design the proposed playground intervention in full. A draft proposal (Appendix I) was presented and discussed with the steering group and the necessary amendments made prior to distribution to a participant advisory group for feedback.

8.2.2 Participant advisory group

Patient and public involvement (PPI) was conducted through a patient advisory group (PAG) consisting of staff and children from the previous chapters in this thesis and a group of third year university students, studying physical activity and PE. The group were contacted and presented with the details of the proposed intervention and the suggested methods of evaluation. Participants were asked to provide feedback using an email feedback template (staff and university PE students) and an online survey (children). Both methods of feedback were structured so that perceived feasibility (acceptability, implementation, practicality) could be established and any further comments/considerations could be addressed. Feedback from this stage was then used to make final amendments to the intervention and evaluation proposal.

Unfortunately, the schools participating in this activity were contacted late in the February of 2020 and due to the COVID-19 pandemic were unable to complete the feedback. This was mainly as a consequence of school closures and reduced face-to-face contact meaning the presentation and delivery of the intervention proposal was not possible. Missing out on the valuable input of the children from the school is acknowledged as a weakness at this stage of the design process. Therefore, it is proposed that prior to the implementation of the proposed pilot intervention a full PPI process be completed with primary school children.

Feedback from the university PE students and a small number of primary school staff was received prior to closure of workplaces, schools and universities. Overall the feedback on the proposal was that it was clear and straight forward and implementation would be possible with support from the research team and the relevant school staff. The primary school teachers all noted that they would need the support of the research team initially to ensure it is implemented correctly. This point reinforces Griggs (2018), who suggested primary school teachers lack the support (i.e., teacher training) to be confident in the delivery of physical activity and PE interventions.

The idea of rewarding and acknowledging children as leaders (Table 8.1; phase 1) and the increased child involvement at a management level (Table 8.1; phase 2) were complemented by the school staff. Amendments to the challenge card template were suggested, to make it more child friendly and include a space to draw their activities out. Furthermore, recommendations on the terminology used and the structure of the self-assessment were advised to make it more appropriate to children and the staff members who would be supporting them. The terminology used was chosen as it aligns to the stages of progression regularly used in the assessment of FMS. This will also be covered in the FMS workshop and the induction session (Table 8.1). However, these points will be considered during a comprehensive PPI process with children prior to implementation. I would like to thank the PAG for their valuable input at this stage.

8.3 Intervention proposal

There is currently no plan to apply for research funding to support the pilot delivery, therefore the intervention has been designed with the aim of utilising the playground environment in its current form (i.e., without changing the physical structure and setting). The intervention consists of three phases (see Table 8.1), underpinned by the SEM for physical activity and health targeting individual, social, environmental and policy factors.

8.3.1 Phase 1

This initial phase of the intervention will take place across two days in the penultimate week of school term (spring term). By training a diverse team of ‘Playground Master’s’ (PM’s) including a range of staff and a selection of year five and six children (stratified by baseline assessment), it is hypothesised that the current negative perception of staff on the playground (chapter 6) will be reduced. Furthermore, using children as additional resources will reduce the demands placed on the overstretched playground staff (chapter 6). Including children in this facilitative role creates a reversal of the adult-child power relationship (Kellett 2005; Jones 2008), placing the children in a leadership role.

Baseline assessments will identify children who are beginning, progressing, achieving and excelling in their FMS competency, using previously validated criteria (Longmuir et al. 2017). Children will be selected at random from each competency level (from the intervention school) and asked to take part in the phase one activities to ensure there is a range of support across all competency levels amongst the PM's.

- *FMS workshop*

The FMS workshop (Table 8.1) will be delivered to children and staff by members of the research team qualified and experienced in teaching/coaching FMS to children (PE teachers and coaches who have completed the UK coaching "how to coach the fundamentals of movement" workshop). The purpose of this phase 1 workshop is to introduce the concept and importance of developing FMS for physical activity participation and health. In addition, the workshop will identify and encourage the most efficient use of playground space, engage and encourage children to step into an active role in managing the playground, and encourage the school and its staff to invest some of their time in this CPD activity. The thesis chapter outcomes targeted by this workshop can be seen in Table 8.1.

- *Playground challenge card workshop*

Staff and children will attend two half day workshops aimed at introducing, discussing and developing the challenge cards (individual cards designed by children) and a challenge card library (database of accumulated cards designed by the children). The first half day workshop will introduce the concept of the challenge card library. Attendees will design and develop some break-time activities to add to those previously developed (by the university steering group) that will help develop some of the FMS covered in the previous workshop. The aim of the challenge cards (Appendix J) are to improve skill competence and increase MVPA levels during break-time. Consideration of previous enjoyment levels will be used by workshop facilitators when supporting children and staff with their challenge cards.

The challenge cards were introduced earlier in this thesis. Children participating in the focus groups in chapter 6 used the challenge card templates to design playground activities for their current playground environment. The feedback from the children during the sessions was positive and the introduction to the challenge card template was brief and easy to understand. The challenge cards are designed so that the participant designing the activity can decide on 100% of the content. The challenge cards encourage children to decide on the task, the skill level, the goals (task or ego), and the criteria for achievement of the competency categories (beginning, progressing, achieving and excelling), (i.e., Mastery motivational climate).

The second half day workshop will continue to develop the challenge card library. In addition, the integration and sustainability of the challenge card library will be discussed with staff and pupils to ensure adequate investment by the school and children. Themes from the previous focus group activities will be used to address perceived barriers to engagement, concerns for use and management of space, and resource availability. An implementation plan will be discussed and agreed before workshop completion (for example, use of electronic versions of the challenge cards). Staff and children completing all the workshops from phase 1 will receive a certificate and a playground master (PM) badge, to be worn during school hours.

Table 8.1 Full details of the proposed intervention and their targeted SEM level.

Intervention component		Details of intervention component	Targeted SEM Level	Informed by chapter outcomes
Phase 1	FMS workshop	Staff and children will attend a half day FMS workshop provided by the FMS steering group. The workshop will include education and practical sessions on the conceptualisation, delivery and assessment of FMS.	Individual, Policy	Chapter 3 – A; pg.192 Chapter 4 – C, D; pg.195 Chapter 5 – C; pg.197 Chapter 6 – C, E; pg.199
	Challenge card workshop	The first half day workshop aimed at introducing the challenge card library. Activities must be developed using resources currently available to the school. Children will be asked to bring in their favourite toy/game/film/cartoon/magazine/book to be used during activity design.	Individual, Social, Environment, Policy	Chapter 4 – A,B,D,E; pg.195 Chapter 5 – B, C, D; pg.197 Chapter 6 – A; pg.199
	Challenge card workshop	Continuation of challenge card library. Integration, sustainability and implementation will be discussed with staff and children in the workshop. Participants who complete all the workshops will graduate as a playground master.	Individual, Social, Environment, Policy	Chapter 4 – B, C, D; pg.195 Chapter 5 – C, D; pg.197 Chapter 6 – B, C, D, E; pg.199
Phase 2	Implementation	PM's will run an introductory session to the challenge cards and the challenge card library. This session will include practical sessions delivered on the playground to give participating children time to become familiar with the concept	Individual, Social, Policy	Chapter 3 – B; pg.192 Chapter 5 – C, D; pg.197 Chapter 6 – A, B, C, E; pg.199
Phase 3	Implementation	Children will be encouraged to participate in a variety of activities throughout the week. PM's will support participants to self-evaluate their performance using the competency criteria at the bottom of each card. Cards that receive special recognition will be highlighted during assemblies and promoted for the following week. Research staff will not be on school premises during phase 3 but will be available for support as and when requested.	Social, Environment, Policy	Chapter 3 – B; pg.192 Chapter 4 – B, C, D; pg.195 Chapter 5 – D; pg.197 Chapter 6 – B, E; pg.199

Abbreviations: FMS, fundamental movement skills; KS, key stage; MVPA, moderate to vigorous physical activity; PM, playground master;

PPI/PAG feedback for phase one activities:

- This phase should be manageable with relevant staff training and support so that the activities can be child led.
- The children will enjoy taking ownership over creating challenge cards but will need support from staff.
- The badge and certificate got wide spread praise as it acknowledges children and staff for their input, making them feel valued and listened to.
- Freedom of choice regarding rules and outcomes (task/ego) will allow for children to choose achievable goals leading to a higher self-confidence.

8.3.2 Phase 2

Phase 2 is designed to develop programme ownership and encourage successful implementation. PM's will run an introductory session about the challenge card library for participating classes and children. The delivery of this session will be led by the playground masters (PM's) but supported by members of the research team. Children participating in the introductory session will have the option of participating in a card designed previously in the workshops or be given time to be able to design their own using a blank template and with support from the PM's. This session will include a practical induction to some of the cards previously developed for children to become familiar with the cards, the progressions and the self-assessment. This will take place on the playground but not during break-time. It is essential that time be made available for participating children to design their own cards if they choose; this could be done in the form of homework or during class time. Break-times should not be used to design cards but can be used to practice and develop them. Challenge cards that are designed outside of curriculum hours (i.e., homework) will be peer assessed by PM's prior to children using them on the playground. However, this activity should be facilitative and not obstructive. Cards that children design in their own time should be rewarded and given appropriate levels of support so that they end up contributing the challenge card library.

PPI/PAG feedback for phase 2 activities:

- Collective agreement that the implementation strategy will work, providing there is initial support from the research team and investment from school staff.
- Focus should be on making it exciting and empowering to children.
- Inclusion of the head teacher is essential for the acknowledgement at senior management and policy level. Concern was raised over implementation in schools with a head teacher that may not prioritise physical activity in school policy.

8.3.3 Phase 3

This final phase is designed to encourage independence and ownership of the programme. It is hypothesised that institutionalisation will occur quicker, and lead to a more sustainable programme in the long term if the PM's are given the opportunity to independently manage the intervention and the challenge card concept.

As the challenge card library grows, participating children will be urged to regularly choose/design a different activity throughout the week. Participating children will be encouraged and supported by the PM's to self-evaluate their performance using the competency criteria at the bottom of each card. Senior management at the school (head teacher or head of KS2) will sit down with one staff PM and two child PM's once each week to select some of the challenge cards they think deserve special credit – these cards will be promoted to KS2 children during assembly at the start of the following week.

PPI/PAG feedback for phase 3 activities:

- Engagement and investment from staff was again mentioned as a crucial factor in successful implementation and practicality.
- Access to playground equipment was perceived as a potential barrier by trainee PE teachers. However, many school staff reported access to an outdoor sports cupboard and the introduction of playtime bags would support this intervention.

- The barriers around ‘acceptable use’ and punishment highlighted in chapter 6 must be acknowledged here to make sure the provision of equipment is positively received and does not undermine the children’s ownership of the intervention activities.

8.4 Proposed methods of evaluation

Although the purpose of the chapter was not to design a full pilot protocol, consideration has been given to how the intervention will be evaluated.

It is proposed that this intervention first be evaluated as a pilot feasibility trial (following registration with the ISRCTN) and will follow the CONSORT guidelines for the reporting of pilot and feasibility trials (Eldridge, Chan, Campbell et al. 2010). Figure 8.1 shows the proposal for the flow of participants through the study.

The study will recruit 70 participants (35 controls and 35 experimental) as this number has previously been described as desirable for good precision and minimal bias due to gaining less than 10% in precision when increasing sample size further (Teare, Munyaradzi, Shephard et al. 2014). Initially, one intervention school (experimental group) and one comparison school (control group) will be recruited. A minimum requirement for inclusion is that the schools have a minimum of one year 5 and one year 6 class of at least 20 children in order to meet the sample sizes needed. However, upon contact with schools it may be necessary to recruit two intervention and two control schools to be confident in recruiting an adequate sample.

The partner primary schools will be matched by the percentage of pupils receiving free school meals and school pupils demographics (age ranges, gender distribution [i.e., % male/female], and ethnicity distribution among attending pupils). Also, schools will matched as closely as possible by playground provision (playground design, environmental characteristics and equipment provision) and features of the playgrounds (play structures, seating availability, general area size, aesthetics), documented using the Environmental Assessment of Public Recreation Spaces (EAPRS) (Saelens, Frank, Auffrey et al. 2006). Using separate, but closely matched schools will avoid contamination between the control group and experimental group that would be likely if both groups were taken from the same primary school. Participants from both groups will be measured at baseline, immediately post intervention (6 weeks) and at follow up (10 weeks) (Figure 8.1).

8.4.1 Outcome measures

Baseline measures will be completed in the final weeks of the term preceding the planned intervention period (spring term). Data will be presented as mean and standard deviation for baseline, post and follow up data. Success criteria will be discussed with academics and professionals in the field of FMS and physical activity prior to the study beginning in order to establish any meaningful differences (MCID) in outcome variables. Mean differences (±95% confidence limits) and effect sizes will be used to establish between groups differences for all outcome measures from baseline to post intervention and follow up.

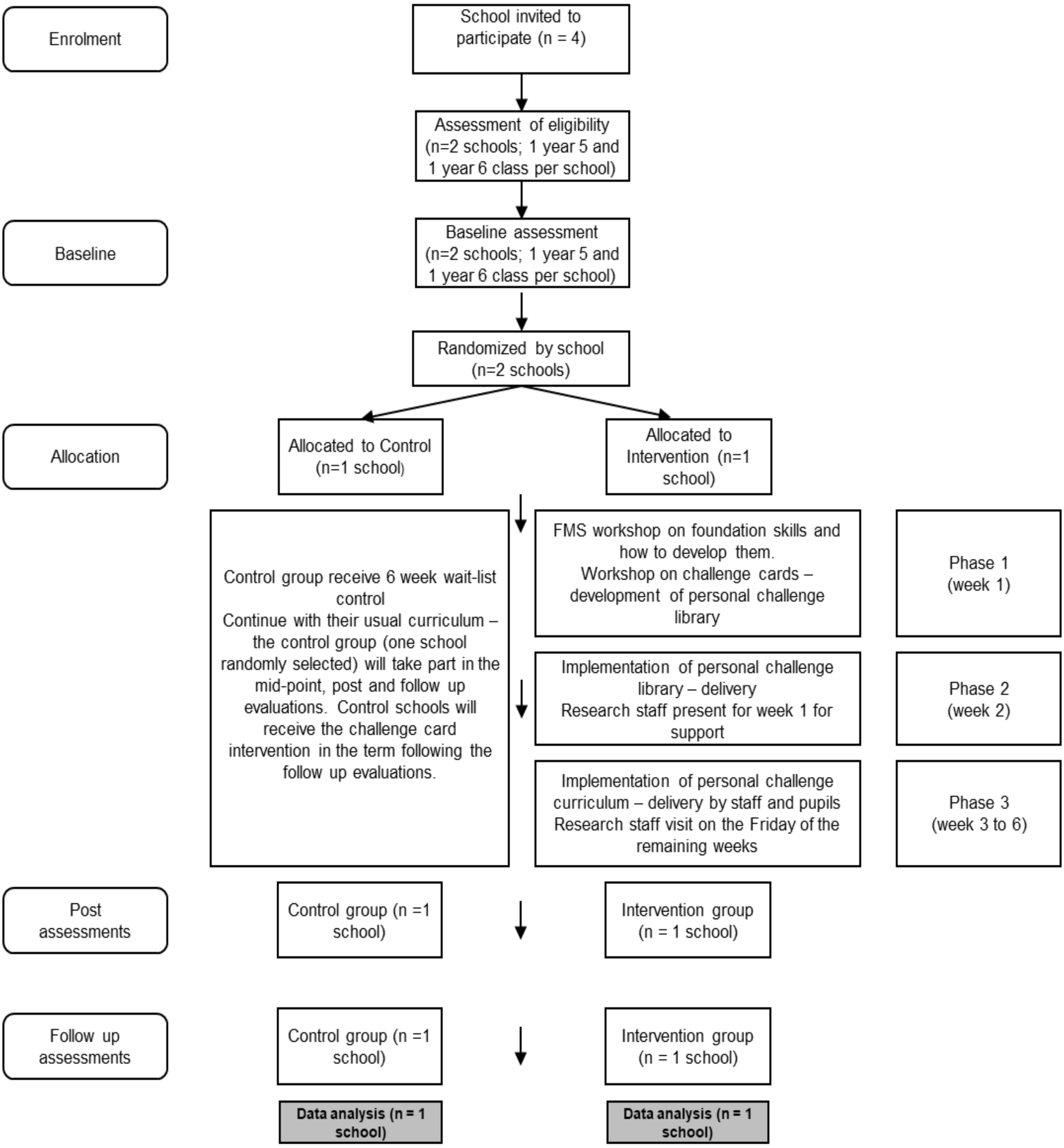


Figure 8.1 Flow of participants through the proposed evaluation

Magnitude-based inferences (MBI) will be used to evaluate the probability that the intervention had a beneficial, trivial or harmful effect on physical activity/FMS levels. Default probabilities for declaring an effect clinically beneficial will be set at <0.5% for harm and >25% for benefit

(Hopkins, Marshall, Batterham, Hanin 2009). Recent developments in the use of MBI and minimal effect testing (Aisbett, Lakens and Sainani 2020; preprint) will be considered.

8.4.1a Fundamental movement skills

FMS competence will be measured using a combined product and process oriented inventory. FMS measurement tools currently considered for use in this evaluation are the Canadian agility and movement skill assessment (CAMSA) (Longmuir et al. 2017), the test of gross motor development (2nd or 3rd Ed.) (Ulrich 2016), the dragon challenge (Tyler et al. 2019) or a combination of measures, to cover all the components of FMS whilst assessing the dynamic nature of FMS. Use of IMU devices (Xsens, Netherlands) were considered given recent evidence supporting their effectiveness (Lander, Nahavandi, Mohamed et al. 2020), however, as this research is in its infancy and limited to small number of skills (Lander et al. 2020) it is unlikely a field based assessment using this method is practical at this time.

8.4.1b Physical activity measurement

Within school and whole day physical activity will be measured using ActiGraph GT3X accelerometers (ActiGraph LLC, Pensacola, FL). These devices have been shown to be appropriate and reliable for the measurement of physical activity in children (Trost 2007; Butte et al. 2012). The devices will be worn for seven consecutive days and set to collect data at 15 second epochs (Evenson et al. 2008). Duncan et al. (2019) identified the variation in physical activity levels measured by accelerometers from different wear sites. Consequently, the use of wrist, hip and ankle worn accelerometers; and the use of multiple wear sites to collect and analyse the most accurate physical activity data will be considered. Physical activity data using these methods will then be analysed using Evenson et al. (2008) cut points for sedentary (< 100 CPM), light physical activity (101 to 2295 CPM), and MVPA (> 2296 CPM). This method will also allow examination of compensatory behaviours as a result of the potentially more active break-times. The school day and break-times will be identified by the participating schools daily timetable.

Direct observation will be used to assess the playground behaviours of children during break and lunch-times. Using a combination of the SOPLAY (McKenzie 2012) and the social factors from the SOCARP (Ridgers et al. 2010) will allow for important contextual and environmental factors to be measured. Video cameras will be used to capture the playground at baseline, midpoint, post-intervention and at follow up.

8.4.1c Strength

A recent review highlighted the positive impact resistance training has on indicators of FMS in youth (Collins, Booth, Duncan and Fawkner 2019). However, studies in the review focussed on product oriented assessments of FMS (Collins et al. 2019) which are likely to show improvements following a resistance training program (e.g., jump height/distance, throwing distance). An individual's muscular strength has direct effects on movement skill development (Malina 2004) with improvements observed in long jump, sprint speed, medicine ball toss, and jump height reported following improvement in muscular strength (Faigenbaum, Kraemer, Blimkie et al. 2009). Initial considerations for the strength assessment for the pilot evaluation are a combination of hand grip dynamometry (kg) and leg dynamometry (kg) with jump height (cm) (counter movement jump) included as a product measure of FMS and lower body power.

8.4.1d Perceived competence

Previous research has suggested that perceived competence has a mediating effect on participation in physical activity in older children (Stodden et al. 2008; Barnett, Morgan, Van Beurden et al. 2008; Barnett et al. 2011). Therefore, it is important to establish levels of perceived competence of participating children to explore the relationship between perceived competence, actual competence and physical activity levels as a result of the intervention. Perceived competence will be assessed using the pictorial scale for young children (Barnett, Ridgers, Zask and Salmon 2015). This scale has been used extensively throughout the literature and has been validated and used successfully in older primary school children (Lopes, Barnett, Saraiva et al. 2016; Morgan et al. 2018).

8.4.1e Feasibility and participant experiences

Participants experiences of the intervention will be collected using semi-structure interviews (adults) and focus groups (children) following baseline (anticipation of intervention), at the end of the third week (removal of research staff), post intervention (effects of intervention components) and at follow up (reflection). Narrative analysis will be completed on the participant accounts, analysed for content and context, focussing on the understandings and feelings of the participants towards the intervention at each stage. Narrative analysis is used in qualitative data synthesis to explore individual participant's stories with an investigative focus (Myers 2009) allowing for exploration of the whole account, rather than fragmented units (Josselson 2011). This qualitative analysis will give the children and staff participating in the study a voice, connecting their experiences throughout the intervention period.

The decision to measure the participant experiences at regular intervals throughout is to ensure the most accurate story is captured and not one influenced by experiences in the final weeks of the intervention. The interviews will focus on the themes of the RE-AIM framework (reach, efficacy/effectiveness, adoption, implementation and maintenance) (Glasgow, Vogt and Boles 1999) to comprehensively measure the perceived effectiveness of the intervention at the individual and organisational levels.

8.5 Additional considerations

8.5.1 Relative Age Effect (RAE)

The FMS measurement methods identified above (the CAMSA and the DC) (Longmuir et al. 2017; Tyler et al. 2019) were developed to offer a more dynamic assessment of children's FMS whilst measuring their capabilities for complex movements (e.g., agility). The validity and reliability of the CAMSA and the DC have been evidenced in children 8 to 12 years of age (Longmuir et al 2017) and 10 to 14 years of age (Tyler et al. 2019), respectively. However, validation in the younger primary school age groups is needed. Furthermore, the RAE phenomenon, described as the relationship observed between an individual's month of birth relative to their peers has been identified when assessing children's FMS proficiency (Birch, Cummings, Oxford et al 2016; Imamoglu and Ziyagil 2017). Physical and maturational advantages that relatively older children have over relatively younger children from the same age group (Mohamed, Vaeyens, Matthys et al. 2009; Imamoglu and Ziyagil 2017) might mask the true outcomes for the FMS assessment when looking at age category norms.

Previous research has found negligible effect sizes for RAE on CAMSA scores (Dutil, Tremblay, Longmuir et al. 2018). The authors tested for RAE in males and females from grade 4 (mean ± SD; 10.6 ± 1.2 years old). According to Lloyd and Oliver (2012), FMS requirements differ for males and females at around 8 and 9 years of age due to maturation occurring earlier in females. It is possible that the RAE may be more distinctive around the younger age groups currently targeted with the CAMSA and therefore a RAE assessment with more sensitive relative age groups brackets is needed. Further, Dutil et al. (2018) split the year into quarters by academic intakes specific to Canadian regions (December to December). A relative older Canadian child from the final months of grade four could be nearly a whole year older than their English counterpart, due to a difference in intakes (English intake is September). For example, the oldest Canadian children in this year would be around 9 years 10 months old in November/December, whilst an English grade 4 child could be 8 years 6 months old at the same point in time.

Therefore, future research should consider validation of the CAMSA and the DC in the younger age groups, whilst exploring the RAE in UK children. Using more sensitive relative age group brackets is needed and would contribute to the RAE research surrounding FMS in UK primary school children.

8.5.2 Foundational movement skills: the future of FMS?

The recent development of a conceptual model for physical activity across the lifespan (Hulteen, Morgan, Barnett et al. 2018) has encouraged debate on the 'skills' that most facilitate physical activity across the lifespan. Hulteen et al. (2018) proposed that the term fundamental movement skills be replaced with the term foundation movement skills to better encapsulate the ‘traditional’ (running, hopping, jumping, throwing etc.) FMS and the ‘non-traditional’ (e.g., cycling, swimming and body weight squat) that influence ones likelihood of continuing on to more specialised or sport specific movement skills. One could argue that a child that becomes ‘proficient’ at cycling, swimming and more strength based ‘foundational movement skills’ (such as the body weight squat proposed in Hulteen’s model) is as likely as a child that ‘masters’ all the traditional FMS of achieving physical activity recommendations and progressing on to more specialised sports skills later in life. This concept has important implications, particularly in the ‘systems’ approach to school based physical activity. The children’s ‘magic wish’ responses from chapter 6 identify a number of physical activity facilitators (e.g., bikes, scooters, trampolines, traditional playground equipment and treasure hunts) that would align to Hulteen et al. (2018) conceptual model.

To my knowledge, there has been little debate surrounding the use of term ‘foundation movement skills’. One could argue that embracing the model is more inclusive of the children who, through many of the socio-cultural moderating variables identified earlier in the thesis may not have opportunities to practice and ‘master’ some of the more traditional FMS. However, it is my opinion that despite Hulteen et al. (2018) acknowledgement of the continued importance of FMS within their model, to replace the term ‘fundamental movement skills’ with ‘foundational movement skills’ runs the risk of disparaging the importance FMS development in childhood. The outcome from the meta-regression in chapter 3, highlights the importance of an accurate conceptualisation of FMS when including them in a physical activity intervention aimed at improving physical activity levels. Therefore, I believe embracing FMS in both the traditional (fundamental) and contemporary (foundational) sense, without a change in language is likely to be more beneficial.

8.6 Future plan

The studies in this thesis, combined with the outcomes from the pilot evaluation will provide a foundation on which to apply for research funding that will support a larger scale, definitive randomised control trial (RCT). The pilot trial and full RCT will be registered with www.clinicaltrials.gov on completion of the protocol paper.

It is also important to consider how the planned playground pilot and larger RCT will align with a whole school ‘systems approach’ (Daly-Smith et al. 2020) to result in more sustainable implementation and longer term behaviour change.

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APPENDICES

Appendix A: PROSPERO registration

UNIVERSITY of York
Centre for Reviews and Dissemination

NHS
National Institute for Health Research

PROSPERO International prospective register of systematic reviews

Review title and timescale

1 Review title
Give the working title of the review. This must be in English. Ideally it should state succinctly the interventions or exposures being reviewed and the associated health or social problem being addressed in the review.
The effect of fundamental movement skill interventions on physical activity levels in 5-11 year olds: a systematic review and meta analysis

2 Original language title
For reviews in languages other than English, this field should be used to enter the title in the language of the review. This will be displayed together with the English language title.

3 Anticipated or actual start date
Give the date when the systematic review commenced, or is expected to commence.
08/05/2017

4 Anticipated completion date
Give the date by which the review is expected to be completed.
07/05/2018

5 Stage of review at time of this submission
Indicate the stage of progress of the review by ticking the relevant boxes. Reviews that have progressed beyond the point of completing data extraction at the time of initial registration are not eligible for inclusion in PROSPERO. This field should be updated when any amendments are made to a published record.

The review has not yet started √

Review stage	Started	Completed
Preliminary searches	No	No
Piloting of the study selection process	No	No
Formal screening of search results against eligibility criteria	No	No
Data extraction	No	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

Provide any other relevant information about the stage of the review here.

Review team details

6 Named contact
The named contact acts as the guarantor for the accuracy of the information presented in the register record.
Michael Graham

7 Named contact email
Enter the electronic mail address of the named contact.
michael.graham@tees.ac.uk

8 Named contact address
Enter the full postal address for the named contact.
Department of Psychology and Sport and Exercise Sciences, School of Social Sciences, Business and Law, Teesside University Middlesbrough United Kingdom TS1 3BA

9 Named contact phone number
Enter the telephone number for the named contact, including international dialing code.

10 Organisational affiliation of the review
Full title of the organisational affiliations for this review, and website address if available. This field may be completed as 'None' if the review is not affiliated to any organisation.

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UNIVERSITY of York
Centre for Reviews and Dissemination

NHS
National Institute for Health Research

Teesside University

Website address:
www.tees.ac.uk

11 Review team members and their organisational affiliations

Give the title, first name and last name of all members of the team working directly on the review. Give the organisational affiliations of each member of the review team.

Title	First name	Last name	Affiliation
Mr	Michael	Graham	School of Social Sciences, Business and Law, Teesside University, Middlesbrough, TS1 3BA
Dr	Liane	Azevedo	Health and Social Care institute, School of Health and Social Care, Teesside University, Middlesbrough, TS1 3BA
Professor	Alan	Batterham	Health and Social Care institute, School of Health and Social Care, Teesside University, Middlesbrough, TS1 3BA
Mr	Matthew	Wright	Sport and Well Being, Student services, Teesside University, Middlesbrough, TS1 3BA
Dr	Alison	Innerd	School of Social Sciences, Business and Law, Teesside University, Middlesbrough, TS1 3BA

12 Funding sources/sponsors

Give details of the individuals, organizations, groups or other legal entities who take responsibility for initiating, managing, sponsoring and/or financing the review. Any unique identification numbers assigned to the review by the individuals or bodies listed should be included.

None

13 Conflicts of interest

List any conditions that could lead to actual or perceived undue influence on judgements concerning the main topic investigated in the review.

Are there any actual or potential conflicts of interest?

None known

14 Collaborators

Give the name, affiliation and role of any individuals or organisations who are working on the review but who are not listed as review team members.

Title	First name	Last name	Organisation details

Review methods

15 Review question(s)

State the question(s) to be addressed / review objectives. Please complete a separate box for each question.

Do fundamental movement skill interventions improve daily levels of total and moderate to vigorous physical activity in primary school aged children?

16 Searches

Give details of the sources to be searched, and any restrictions (e.g. language or publication period). The full search strategy is not required, but may be supplied as a link or attachment.

Literature searches will be completed by an information specialist. Databases selected for searching are MEDLINE, CINAHL, PubMed, Web of Science, SportDiscus, EMBASE, ERIC, Scopus. Reference lists of returned searches will be screened for relevant articles. Each database will be searched from the date of the earliest available record until the specified search dates of this review. Grey literature databases will not be searched. Database searches will be re-run in December 2017 prior to analyses to account for any eligible articles published since the primary searches. The search strategy will be built to include all search terms/keywords using the PICO approach for systematic reviews. All terms/words associated "Children", "fundamental movement skills", "controlled" and "physical activity" will be searched using the Boolean operator 'OR' and then combined using the AND Boolean operator. (e.g. "Children" OR

"Child" AND "Fundamental movement skills" OR "Motor skills" AND etc.).

17 URL to search strategy

If you have one, give the link to your search strategy here. Alternatively you can e-mail this to PROSPERO and we will store and link to it.

I give permission for this file to be made publicly available

No

18 Condition or domain being studied

Give a short description of the disease, condition or healthcare domain being studied. This could include health and wellbeing outcomes.

In this study we will investigate fundamental motor skills and physical activity in children. Physical activity defined as any bodily movement produced by skeletal muscle that results in energy expenditure above resting levels (WHO 2010). Children can expect both physiological and psychological health improvements when they take part in regular physical activity (Cavill et al 2001). Fundamental movement skills (FMS) are believed to be an important contributor to the level of physical activity children take part in. FMS consist of 3 main constructs; locomotor (run, hop, jump, slide, gallop, leap); object control (strike, dribble, kick, throw, underarm roll, catch); and balance/stability skills (non locomotor skills such as body rolling, bending and twisting) (Gallahue, Ozmun and Goodway 2012). Higher gross motor competence attenuates the decline in physical activity throughout childhood (Lopes et al 2011) and is important to physical development and physical activity across the developmental lifespan (Stodden et al 2012). A number of recent publications add further support to this belief, highlighting positive association between motor skill competence and physical activity (Barnett et al 2009, Barnett et al 2016, Catuzzo et al 2016, Chan, Ha, Ng 2016). Furthermore, low levels of motor competence are associated with lower levels of cardio respiratory fitness (Cohen et al 2015). The teaching/delivery of FMS programmes/interventions is important, as FMS are not learnt naturally over time (Logan et 2012); hence the growing popularity of school and community based interventions.

19 Participants/population

Give summary criteria for the participants or populations being studied by the review. The preferred format includes details of both inclusion and exclusion criteria.

Inclusion: 5-11 year old (at baseline) primary school children Participants/sample stated as healthy (no weight/BMI restriction) Exclusion: -Preschool (11 years old) children at baseline -Individuals with a recognised developmental disorder/disability/illness affecting usual learning/movement -studies involving only overweight/obesity as a targeted population - studies looking solely at special populations (SEN, Learning difficulties, visual impairments).

20 Intervention(s), exposure(s)

Give full and clear descriptions of the nature of the interventions or the exposures to be reviewed

Inclusion: Any Intervention aimed at improving fundamental movement skills (FMS). Identified as FMS as stated by author or identified by use of a validated FMS measurement tool. The reviewers will judge the intervention as a FMS intervention if it targets any one of three main constructs of FMS; locomotor (run, hop, jump, slide, gallop, leap); object control (strike, dribble, kick, throw, underarm roll, catch); and balance/stability skills (non locomotor skills such as body rolling, bending and twisting) (Gallahue, Ozmun and Goodway 2012). There will be no restriction on delivery/instructor method (external coach, teacher, researcher, and community group), duration or setting (primary school, community group, day care etc.). Exclusion: no identifiable FMS intervention by above method. Laboratory interventions and interventions that are delivered only at home.

21 Comparator(s)/control

Where relevant, give details of the alternatives against which the main subject/topic of the review will be compared (e.g. another intervention or a non-exposed control group).

Inclusion: - comparison/control group that is identified as no treatment, usual care or waiting list control. Studies involving multiple groups with a true control group will also be included. Usual care must be defined as an intervention not involving any form of physical activity. Exclusion: -Non controlled trials. Alternative treatment, physical activity, or exercise instruction without a true control group.

22 Types of study to be included

Give details of the study designs to be included in the review. If there are no restrictions on the types of study design eligible for inclusion, this should be stated.

Inclusion: -Controlled (RCT and Non-RCT) in peer reviewd journals with full text available in English Exclusion: -Non-controlled studies, longitudinal studies, previous review articles, non-English full text and grey literature.

23 Context
Give summary details of the setting and other relevant characteristics which help define the inclusion or exclusion criteria.
Inclusion: Interventions aimed at improving FMS in primary school aged children (5-11 years old) to include interventions delivered in the community and within the primary school by community groups. No restrictions on delivery method (Instructor type etc. see section 20) Exclusion: home or lab based interventions.

24 Primary outcome(s)
Give the most important outcomes.
The primary outcome is the daily levels of either total physical activity or moderate to vigorous physical activity (i.e., not just school day physical activity levels).

Give information on timing and effect measures, as appropriate.
Comparisons will be made between measurements at baseline (pre intervention) and post intervention, if this is not available, data will be extracted from the next available follow up. Due to the developmental nature of FMS, follow up data will also be used in the sub group analysis as the true effect may be delayed due to onset of mastery of the skill. Physical activity, either daily total or MVPA (threshold defined by authors will be used), would need to be measured using previously validated objective measures (accelerometry). Fundamental movement skills should be measured using previously validated methods (TGMD-2/3, M-ABC2, CHAMP's, PDMS-2 etc.)

25 Secondary outcomes
List any additional outcomes that will be addressed. If there are no secondary outcomes enter None.
Change in FMS skill score will be recorded as a mediator variable (i.e., improvements in FMS linked to increase physical activity).

Give information on timing and effect measures, as appropriate.
from baseline to post intervention/follow up.

26 Data extraction (selection and coding)
Give the procedure for selecting studies for the review and extracting data, including the number of researchers involved and how discrepancies will be resolved. List the data to be extracted.
Results from database searches will be exported to End Note. Two independent reviewers will initially screen titles and abstracts from these articles and articles returned from additional sources. This process will identify if articles meet the eligibility criteria (inclusion/exclusion) selected for this review. Any disagreements in eligibility will be discussed and agreed by a third reviewer. Eligible articles will be retrieved and read in full by the same two reviewers. Any disagreements during this process will be discussed with a third reviewer. A hierarchical exclusion method will be used to exclude studies by order of importance using the defined exclusion criteria. Two researchers will independently gather the following information from the eligible articles using a standard data extraction form: Citation details, Study design (including method used to measure physical activity and fundamental movement skills); Processing criteria for Physical activity data (MET level for MVPA, minimum wear time, cut points, epochs used, counts per minute); intervention details; study population; study setting; participant demographics; age group/school year; baseline measures; outcomes and intervention duration; post/follow up details; Control group format; measures of compliance/adherence; acceptance of intervention (pupils, staff, parents) and funding sources. Any discrepancies will be discussed with a third reviewer. Authors will attempt to acquire any data missing from studies via contacting the corresponding author by phone, email, and/or post.

27 Risk of bias (quality) assessment
State whether and how risk of bias will be assessed, how the quality of individual studies will be assessed, and whether and how this will influence the planned synthesis.
The Cochrane risk of bias assessment tool (RoB 2.0) and the Risk of Bias in Non randomised studies of Interventions (ROBINS-I) will be used by two independent reviewers to evaluate risk of bias of eligible articles. Disagreements will be resolved by discussion with a third reviewer.

28 Strategy for data synthesis
Give the planned general approach to be used, for example whether the data to be used will be aggregate or at the level of individual participants, and whether a quantitative or narrative (descriptive) synthesis is planned. Where appropriate a brief outline of analytic approach should be given.
Both narrative synthesis and comprehensive meta-analysis methods will be used. Comprehensive meta-analysis software (CMA) will be used to perform a Random Effect Meta-Analysis in order to present a prediction interval (expected range of true effects in similar studies). The Preferred Reporting Items for Systematic Reviews and Meta-

Analysis (PRISMA) guidelines/statement will be used when constructing and reporting the method and findings of this systematic review.

29 Analysis of subgroups or subsets

Give any planned exploration of subgroups or subsets within the review. 'None planned' is a valid response if no subgroup analyses are planned.

If data is present, meta-regression will be conducted on: 1) type/method of deliver (instructor/researcher/teacher/setting) 2) Weight status at baseline 3) age at baseline 4) Sex (male/female) 5) SES 5) Duration of sessions 6) Duration of intervention 7) Number of sessions within the intervention period 8) FMS subgroups (locomotor, object control, stability/balance) 9) Timing of post intervention/follow up 10) Environment/setting for FMS intervention.

Review general information

30 Type and method of review

Select the type of review and the review method from the drop down list.

Meta-analysis, Systematic review

31 Language

Select the language(s) in which the review is being written and will be made available, from the drop down list. Use the control key to select more than one language.

English

Will a summary/abstract be made available in English?

Yes

32 Country

Select the country in which the review is being carried out from the drop down list. For multi-national collaborations select all the countries involved. Use the control key to select more than one country.

England

33 Other registration details

Give the name of any organisation where the systematic review title or protocol is registered together with any unique identification number assigned. If extracted data will be stored and made available through a repository such as the Systematic Review Data Repository (SRDR), details and a link should be included here.

34 Reference and/or URL for published protocol

Give the citation for the published protocol, if there is one.

Give the link to the published protocol, if there is one. This may be to an external site or to a protocol deposited with CRD in pdf format.

I give permission for this file to be made publicly available

Yes

35 Dissemination plans

Give brief details of plans for communicating essential messages from the review to the appropriate audiences.

This process will form part of a PhD thesis and the paper will be formally submitted to a leading journal in this field. An additional aim is also to present the findings from this review and meta-analysis at an appropriate conference. Schools in the area will be made aware of the findings from this review.

Do you intend to publish the review on completion?

Yes

36 Keywords

Give words or phrases that best describe the review. (One word per box, create a new box for each term)

Systematic review

meta analysis

UNIVERSITY of York
Centre for Reviews and Dissemination

NHS
National Institute for Health Research

Primary school

children

Fundamental movement skills

physical activity

MVPA

37 Details of any existing review of the same topic by the same authors
Give details of earlier versions of the systematic review if an update of an existing review is being registered, including full bibliographic reference if possible.

38 Current review status
Review status should be updated when the review is completed and when it is published.
Ongoing

39 Any additional information
Provide any further information the review team consider relevant to the registration of the review.

40 Details of final report/publication(s)
This field should be left empty until details of the completed review are available.
Give the full citation for the final report or publication of the systematic review.
Give the URL where available.

Appendix B: Eligibility criteria for chapter 3

Exclusion criteria for study selection with respective codes and descriptions

Code	Description	Details
D	Duplicate	Duplicate result returned from another database
D (d)	Duplicate: same database	Duplicate result returned from the same database
X	Excluded: irrelevant topic	Topic of a different discipline
E1	Excluded: not original research	Reviews, surveys, opinion pieces, books, periodicals, editorials, non-academic/non-peer-reviewed text (grey literature).
E2	Excluded: research design	Cross sectional, Longitudinal, no control group or use of alternative treatment (i.e. involving alternative form of physical activity)
E3	Excluded: participants <5 and >11 years of age	Preschool/early years or secondary/adolescent/youth. Participants not between age range of 5 and 11 years at baseline
E4	Excluded: special population	SEN, Overweight/Obese, DCD, Visual impairments, recognised development disorder/disability/illness affecting usual movement/development
E5	Excluded: No identifiable FMS intervention	No FMS intervention stated by author or identified by use of a validated FMS measurement tool. No individual construct identified using Gallahue, Ozmun and Goodway (2011). Reviewer unable to identify FMS from methodology.
E6	Excluded: intervention setting	Either laboratory based or home based intervention
E7	Excluded: no English FT	Full text not available in English.
E8	Excluded: did not report a measure of daily level of total or MVPA	Unable to make comparison between baseline and post intervention/follow up measures. No pre to post intervention measure for total or MVPA.
E9	Excluded: No valid/objective measure of physical activity	Did not use a previously validated objective measure for physical activity (i.e. accelerometry).

FT – Full text; SEN – Special educational needs; DCD – Developmental Coordination Disorder; FMS – Fundamental Movement Skills; MVPA – Moderate to vigorous physical activity; TGMD – Test of gross motor development; M-ABC-Movement assessment battery for children; CHAMP's – Children's activity and movement in preschool study; PDMS – Peabody developmental motor scale

Appendix C: Risk of Bias: individual study scores

Risk of Bias assessment for Non-Randomised Controlled Trials (ROBINS-I)

Bias due to:	confounding	selection of participants	classification of interventions	deviations from intended interventions	missing data	measurement of outcomes	selection of the reported result	Overall*
Bryant et al. 2017	Low	Low	Low	Serious	Low	Low	Low	Serious
Fairclough et al. 2016	Moderate	Low	Low	Low	Low	Low	Low	Moderate
Johnstone et al. 2017	Serious	Serious	Low	Serious	Serious	Serious	Low	Serious
Nathan et al. 2017	Moderate	Low	Low	Low	Low	Low	Low	Moderate
Weber et al. 2017	Low	Low	Low	Low	Low	Low	Low	Low
Wong et al. 2016	Low	Low	Low	Serious	Serious	Moderate	Low	Serious

Risk of Bias assessment for Randomised Control Trials; ROB 2.0

Study name	1	1a	2	3	4	5	Total
Adab et al. 2018	L	L	L	L	L	L	L
Aivazidis et al. 2019	L	L	L	SC	L	L	SC
Barnes et al. 2015	L	N/A	L	L	L	L	L
Breslin et al. 2019	L	L	L	L	L	L	L
Caballero et al. 2003	L	N/A	L	SC	L	H	H
Cohen et al. 2015	SC	L	L	L	L	L	SC
Jago et al. 2014	L	L	L	L	L	L	L
Jago et al. 2019b	L	L	L	L	L	L	L
Johnstone et al. 2019	SC	L	L	L	L	L	SC
Kriemler et al. 2011	H	L	L	H	H	L	H
Martin and Murtagh 2017	L	L	L	L	L	L	L
Morgan et al. 2011	L	N/A	L	L	H	L	H
Morgan et al. 2014	L	N/A	L	L	H	L	H
Morgan et al. 2018	L	N/A	L	L	H	L	H
Sallis et al. 1997	L	H	H	L	L	L	H
Salmon et al. 2008	L	L	SC	L	L	L	SC
Sutherland et al. 2017	L	L	L	L	L	L	L
Taylor et al. 2018	L	L	L	L	L	L	L
Telford et al. 2016	L	L	L	L	L	L	L

Abbreviations: H = High risk; L = Low risk; SC = Some concerns

Appendix D: Meta-analysis data output table

Meta-analysis output

	mean diff	SE	Var	low	upper	Z value	P value
Salmon 2008	18.2	1.61	2.58	15.1	21.3	11.3	0.00
Cohen 2015	12.7	4.72	22.3	3.45	21.9	2.69	0.01
Martin 2017	4.8	7.44	55.4	-9.79	19.4	0.65	0.52
Telford 2016	0.3	1.83	3.35	-3.29	3.89	0.16	0.87
Kriemler 2010	9.0	3.99	15.9	1.17	16.8	2.25	0.02
Jago 2014	4.3	2.18	4.75	0.002	8.57	1.97	0.05
Sutherland 2017	1.9	2.77	7.69	-3.48	7.39	0.71	0.48
Adab 2018	-3.9	4.89	23.9	-13.5	5.65	-0.81	0.42
Taylor 2018	-4.1	4.85	23.5	-13.6	5.42	-0.84	0.40
Fairclough 2016	9.8	12.7	160.3	-15.0	34.6	0.77	0.44
Weber 2017	-16.4	11.0	121.4	-38.0	5.17	-1.49	0.14
Jago 2019	-0.8	0.38	0.15	-1.50	0.003	-1.97	0.05
Breslin 2019	2.1	3.12	9.72	-4.01	8.21	0.67	0.50
Johnstone 2019	10.7	2.08	4.32	6.63	14.8	5.15	0.00
Pooled effect	**4.25**	**2.34**	**5.46**	**-0.33**	**8.83**	**1.82**	**0.07**

Meta-regression Model 1: If a measure of FMS used with at least one of Logan et al. (2018) criteria

Covariate	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	**t-value df = 10**	**2-sided P-value**
Intercept	1.5772	1.7494	-2.3206	5.475	0.9	0.3885
FMS measure and Logan et al. 2017 criteria	12.8205	2.831	6.5128	19.1283	4.53	0.0011

Statistics for Model 1

Test of the model: Simultaneous test that all coefficients (excluding intercept) are zero
F = 9.30, df = 3, 10, p = 0.0031

Goodness of fit: Test that unexplained variance is zero
Tau^2 = 8.4292, Tau = 2.9033, I^2 = 52.05%, Q = 20.86, df = 10, p = 0.0221

Proportion of total between-study variance explained by Model 1
R^2 analog = 0.85

Meta-regression Model 2: Additive effect of using each of Logan et al. (2018) three FMS criteria

Covariate	**Coefficient**	**Standard Error**	**95% Lower**	**95% Upper**	**t-value df = 10**	**2-sided P-value**
Intercept	1.1815	1.6258	-2.4409	4.804	0.73	0.484
logan et al. 1 criteria used	-0.092	2.5784	-5.8371	5.6531	-0.04	0.9722
logan et al. 2 criteria used	9.5185	3.6329	1.4239	17.613	2.62	0.0256
logan et al. 3 criteria used	15.7346	3.0619	8.9123	22.5569	5.14	0.0004

Statistics for Model 1

Test of the model: Simultaneous test that all coefficients (excluding intercept) are zero

F = 11.16, df = 3, 10, p = 0.0016

Goodness of fit: Test that unexplained variance is zero

Tau^2 = 6.0360, Tau = 2.4568, I^2 = 38.21%, Q = 16.18, df = 10, p = 0.0945

Proportion of total between-study variance explained by Model 1

R^2 analog = 0.89 (89%)

Appendix E: Chapter 4 and Chapter 5 ethical approval confirmation

From: Research Ethics Committee [mailto:unity@tees.ac.uk]
Sent: 22 May 2017 11:45
To: Graham, Michael (SSSL) <Michael.Graham@tees.ac.uk>
Subject: Ethics Application SSSBLREC055 Approved

Dear Graham, Michael (SSSL),

This email has been sent to notify you that the following ethics application has been approved by the committee:

Application Ref: SSSBLREC055

Project Title: Does the playground environment matter?

Please note: If the research should change or extend beyond the indicated dates, the application must be resubmitted detailing the nature of the proposed changes and/or the revised end date for re-approval by the Chair of the Ethics Committee.

Kind regards,

Dr Christopher Wilson

Chair

Research Ethics Committee

School of Social Sciences, Business and Law

Appendix F – Inter-observer reliability

Table of Reliability of observers against the lead observer (MG) score for assessment videos.

Gold assessment	Sedentary			LPA			MVPA		
Observer ID	ICC; (95%CI)	IOA %	IRR k	ICC; (95%CI)	IOA %	IRR k	ICC; (95%CI)	IOA %	IRR k
AI	0.96; (0.92-0.98)	89	0.69	0.97; (0.93-0.98)	82	0.60	0.97; (0.93-0.98)	89	0.75
MW	0.99; (0.97-0.99)	89	0.71	0.99; (0.98-0.99)	82	0.51	0.98; (0.98-1.00)	93	0.83

Abbreviations: CI = Confidence Intervals; ICC = Inter-class correlation coefficient; IOA = Inter observer agreement; IRR = Inter-rater reliability; LPA = light physical activity; k = Cohen's Kappa; MVPA = moderate to vigorous physical activity

Appendix G: Chapter 6 ethical approval confirmation

PRIVATE AND CONFIDENTIAL

21/06/2019

School of Health & Social Care

Teesside University

Dear Dr Innerd,

Study No 250/18 - The effect of a short term playground intervention to enhance motor skills and physical activity in primary school children – intervention development. Researcher: Michael Graham. Supervisor: Alison Innerd.

Decision: Provisionally Approved Subject to Amendments (Chair's Action)

Thank you for your application to the School of Health & Social Care Research Ethics Sub-Committee. The Committee reviewed your application on 15/05/2019 and would offer the Comments below.

Please respond to each of the comments, with a written statement detailing how you have chosen to address them. Please email that (directly to the Chair) with a copy of any documents that you have changed, in any way and any new documents, cross referenced to the relevant response(s). Please show all changes, to all documents, using either:

From: FD

Sent: 08 July 2019 05:14:20

To: SOHSC-Ethics

Subject: Fw: Study No 250/18: Amendments

Dear Dr Innerd,

Thanks for your email. I can confirm that you have satisfactorily addressed all of the points raised by the committee. This study can proceed as soon as you receive this email (no need to wait for a letter from x)

Best wishes,

Appendix H: Chapter 6, Staff questionnaire/interview structure

Focus group and interview topic guide – Barriers and facilitators to a physically active playground

Please use the topics below when facilitating discussions around barriers and facilitators

If staff members prefer they can fill out their opinions on the topics below. Please use additional sheets of paper where necessary as the space provided below will be insufficient.

1. – What things prevent or promote physical activity during break-times? Why? Does anything need to change?

2. – What skills (physical, social and mental) do you think children need to be active during break-times? (for example, if equipment is provided – what prerequisite skills do children need to use the equipment effectively?

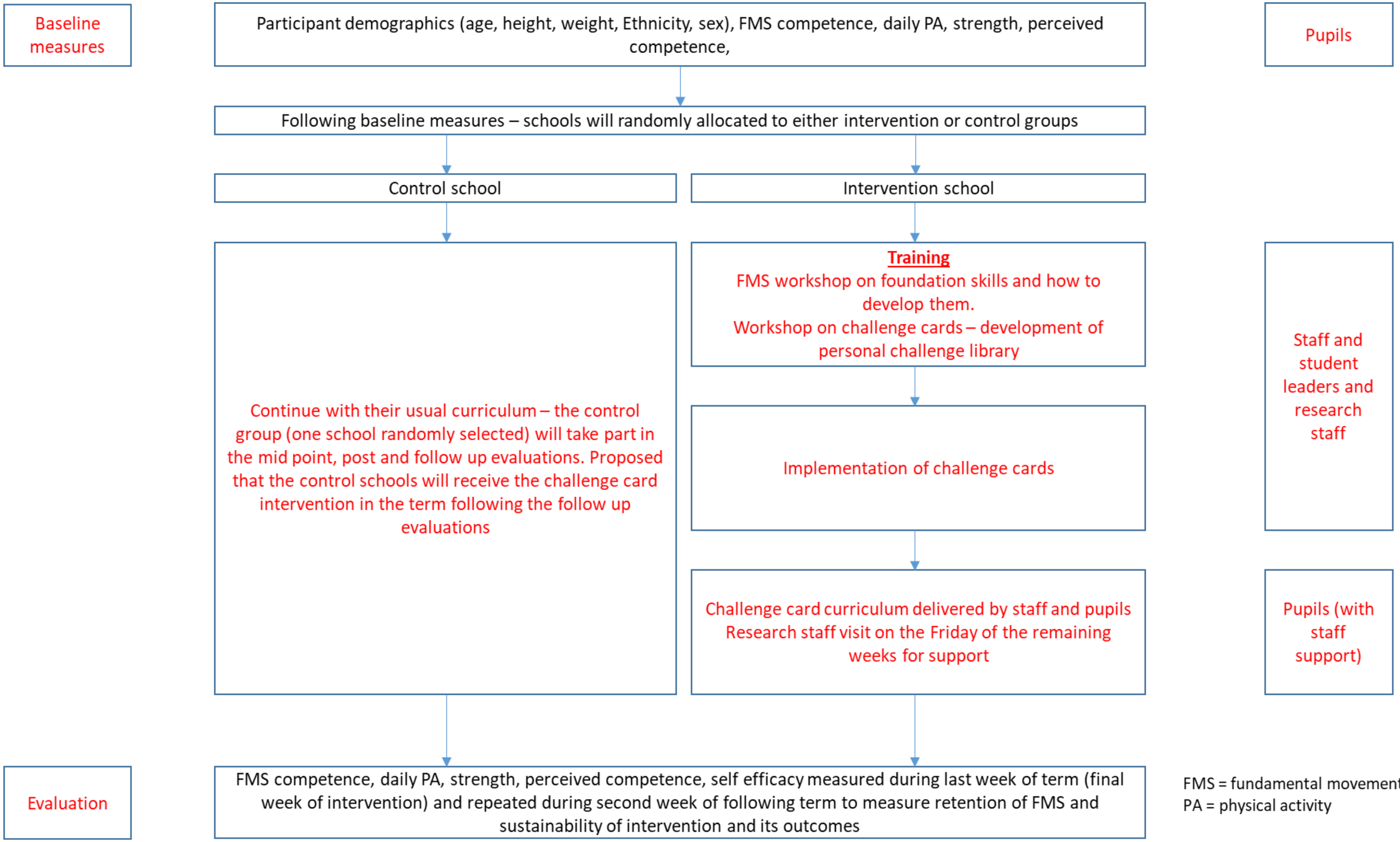
3. – What do you think the role of the playground supervision is? How are they perceived by the pupils and what do you think the effects of their presence has on physical activity levels?

4. - Should any future playground intervention/activities be research led, teacher led, pupil/peer led?)

5. - Should future intervention/activities be designed to challenge individual children or designed for the playground population as a whole

6. **Magic wish** - If you (the staff member) could request one thing for the children to use at break-time, what would it be?

Appendix I: Initial draft intervention proposal



FMS = fundamental movement skills
PA = physical activity

Appendix J: Challenge card and suggested amendments

The template below has been changed to provide a large dedicated space for children to draw out their task/activity. The small space that was originally on the front of the card has been moved to the reverse of the page to allow a full page spread.

FRONT PAGE

Participant ID:

Age:

TASK No.

Skills Categories

Equipment needed

Suggested area(s)

Beginning Instructions

Progressing - instructions

Achieving – instructions

Excelling – instructions

	Pupil*	Staff/Peer#
Beginning		
Progressing		
Achieving		
Excelling		

*Pupil to tick the box on completion of each skill level

Staff or peer (friend) to tick box on observation of each skill level

REVERSE PAGE

Please use the space below to draw your playground activity. Use labels and arrows to help people who want to take part understand what they need to do.

STOCK IMAGE